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ABSTRACT

This report represents the National Science Foundation's third projection analysis of science and engineering doctorate supply and utilization. This 1974 study incorporates several new elements. New data have been used, such as the results of the 1973 Survey of Doctoral Scientists and Engineers, and different methodologies were developed, such as those used for the projection of academic and "other science/engineering" utilization. Furthermore, the overall projections have been limited to broad areas of science, such as the physical sciences, engineering, etc., since too little is currently known about interfield mobility to make further breakdowns by individual science and engineering fields very meaningful. After the summary and introduction, the general environment for projections, the doctorate scientist and engineer utilization in 1972, and projected supply and projected utilization are presented. Appendixes include technical notes, selected related publications, text tables and charts. (Author/PG)

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PROJECTIONS of SCIENCE and ENGINEERING DOCTORATE SUPPLY and UTILIZATION 1980 and 1985

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FOREWORD

This report represents the National Science Foundation's third projection analysis of science and engineering doctorate supply and utilization. Previous studies were carried out in 1969 and 1971. The new study was started because of the realization that projections depend upon assumptions that should be periodically reexamined and revised if necessary. Changes in enrollment, funding and utilization patterns, which had just become evident when previous projections were made in 1969 and 1971, have persisted and can now be identified as definitive trends. Whether they will prevail remains to be seen. There seems little doubt, however, that the changes that started in the early seventies are likely to produce pronounced qualitative changes in the training of science and engineering doctorates as well as in their utilization.

This 1974 study incorporates several new elements. New data have been used, such as the results of the 1973 Survey of Doctoral Scientists and Engineers. Different methodologies were developed, such as those used for the projection of academic and "other science/engineering" utilization. New projections of related parameters were prepared by NSF, such as those pertaining to R&D funding and higher education enrollments in science and engineering. Furthermore, the overall projections have been extended beyond 1980 to 1985. Disaggregation by field again has been limited to broad areas of science, such as the physical sciences, engineering, etc., since too little is currently known about interfield mobility to make further breakdowns by individual science and engineering fields very meaningful.

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Users of this study should recognize that its projections represent numerical results derived from models of the science and engineering manpower system. The projections evolve from two alternative sets of explicitly stated assumptions which enable the reader to select those which he considers as most likely. Furthermore, sensitivity analyses are presented for possible further adjustment of the numerical results. An assessment of the most likely set of assumptions is made in the report and these have been integrated into the Probable Model. It is realized, however, that crystal balls are cloudy when dealing with such complex phenomena as career and employment decisions or the socioeconomic systems that affect them.

Charles E. Falk
Director
Division of Science Resources Studies

February 1975

acknowledgments

While many staff members of the NSF Division of Science Resources Studies contributed to this effort, the following warrant specific acknowledgment:

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INTRODUCTION

This study, like its two predecessors,[1] is premised upon a number of explicit and implicit assumptions about the future. While numerous scenarios of the supply and utilization of doctorates are possible, it is not practical to explore all possibilities. Thus, two sets of models of both supply and utilization were developed. A summary of the factors and assumptions used and their impact sensitivity on the projections are presented in chapter II. These two sets are called "Probable" and "Static." As implied by the name, the Probable Models are thought to reflect the more likely course of future events as now perceived. The results of the Static Models are provided as benchmarks for comparison and to illustrate the effect of the continuation of past and current practices.

[1] National Science Foundation, *Science & Engineering Doctorate Supply & Utilization, 1968-80* (NSF 69-37) and *1969 & 1980 Science & Engineering Doctorate Supply & Utilization* (NSF 71-20) (Washington, D C 20402: Supt of Documents, U.S. Government Printing Office), 1969 and 1971

The Static Supply Model assumes little change in past trends of science and engineering (S/E) undergraduate and graduate student behavior, and does not consider specifically the effects of future labor market conditions. On the other hand, the Probable Supply Model assigns double weight to the trends of the last five years, thus placing greater emphasis on the effects of recent labor market conditions and other developments which are expected to prevail over the projection period.

While the Probable Supply Model implicitly reflects some market factors, an attempt was made also to develop a recursive market model which would incorporate an explicit annual feedback from the job market to the career choice of students. Because of lack of sufficient data for periods of imbalance, however, it was not possible to utilize this model. It is hoped that the approach described in chapter V can be used in future projections when more data points may be available.

The Static Utilization Model attempts to reflect past and current patterns and trends in the employment of doctorates in relation to total scientist/engineer employment in each major activity (academic, nonacademic R&D and other S/E employment).

The Probable Utilization Model assumes a greater degree of replacement of nondoctorate scientists/engineers leaving the labor force by doctorates, and/or an increase in the share of doctorates hired for new positions—phenomena termed "enrichment." This model represents what is thought to be a more likely scenario given the relatively abundant supply of doctorates and the potentially slow growth of the traditional activities of most doctorates—teaching and research and development.

Caveats

The nature of the projection r
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Projections are not predictic
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Caveats

The nature of the projection methodology and the assumptions and factors used make it imperative to emphasize a number of caveats which should be kept in mind when examining the results of this analysis.

Projections are not predictions. Projections are derived from statistical models based on trends and an awareness of current happenings. Thus, they produce a range of possible future situations based on definitive assumptions of specific situations and no significant breaks in trends.

No false sense of precision should be attributed to numerical values in view of the limitations of the data and methodologies, the complexities of the system, and the unpredictability of future events. The last factor requires special emphasis since, by their very nature, long-term projections cannot take into consideration factors impossible to anticipate at the time the projections are made. With an appropriate understanding of these uncertainties, projective analyses of this kind do produce broad indications of likely balances or imbalances and can provide insight into the quantitative effects of various parameters.

Because of changing situations, projections which are revised periodically can provide particular insight into movements toward or away from balance. The directions of these movements are more significant indicators than the degrees of imbalance shown by a single projection.

Each major area of science includes a number of specific fields or disciplines (e.g., physics, biology, electrical engineering, economics, statistics) that may differ from each other in their supply-utilization relationship. Thus, it must not be assumed that the aggregate situation for a broad area of science (e.g., physical sciences) is necessarily applicable to individual disciplines within the area.

Though a certain amount of mobility occurs across the major S/E areas, these projections assume no significant changes in established mobility patterns. Imbalances in supply and utilization configurations in a particular area, however, could produce mobility changes.

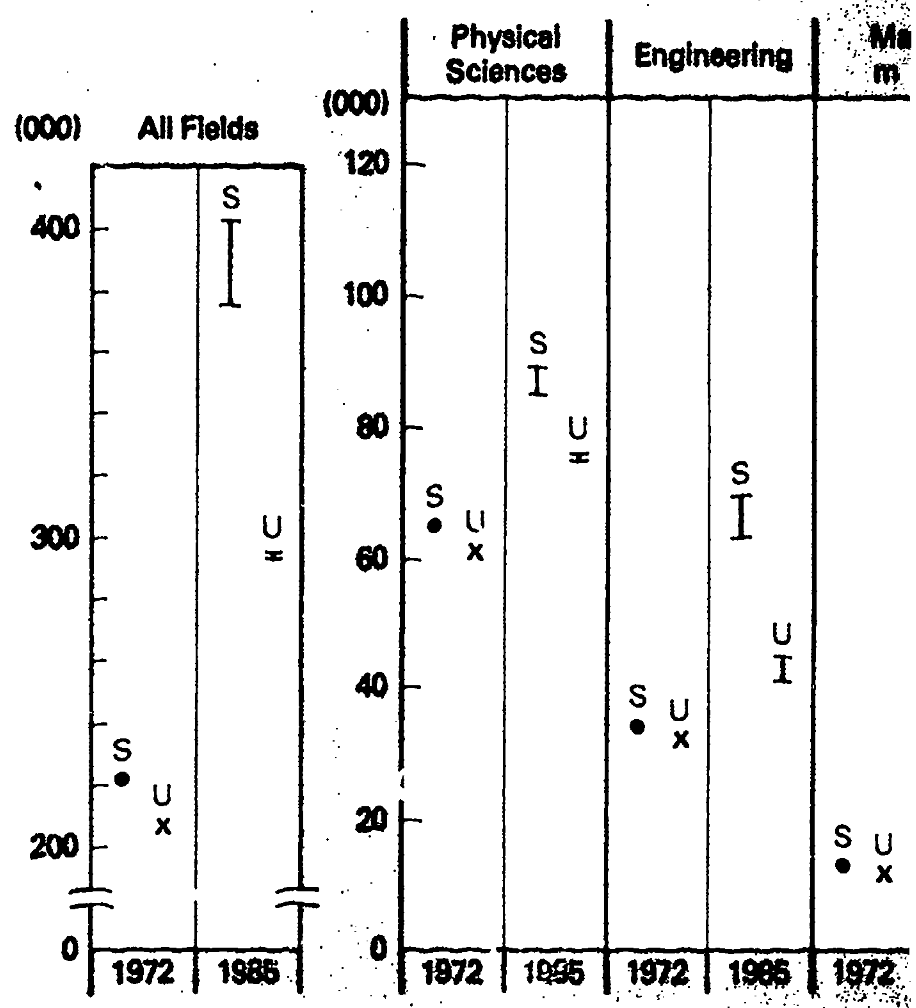
Chapter I. SUMMARY OF FINDINGS

Overall Findings

• The projections based on the two models indicate that between 375,000 and 400,000 science and engineering (S/E) doctorates would be available to the U.S. economy in 1985, compared to about 295,000 available positions in S/E-related activities (chart 1). The two models of utilization produce overall projections of about the same magnitude though utilization by S/E activities (academia, nonacademic research and development, etc.) in each model differ substantially.

• As compared to previous studies, these projections indicate a trend toward increasing imbalances between supply and utilization, which would result in more non-S/E utilization of S/E doctorates, possibly in some outright unemployment (chart 1 and table 1). The magnitude of the unemployment is difficult to project, but is expected to be relatively small since individuals with doctorate education are likely to find some sort of employment—possibly in non-S/E activities or in underutilization of their training.

Chart 1. Supply and utilization ranges of scie[...] 1972 and 1985



NOTE: Vertical bars indicate range between Probable and Static Model values [...]
SOURCE: National Science Foundation

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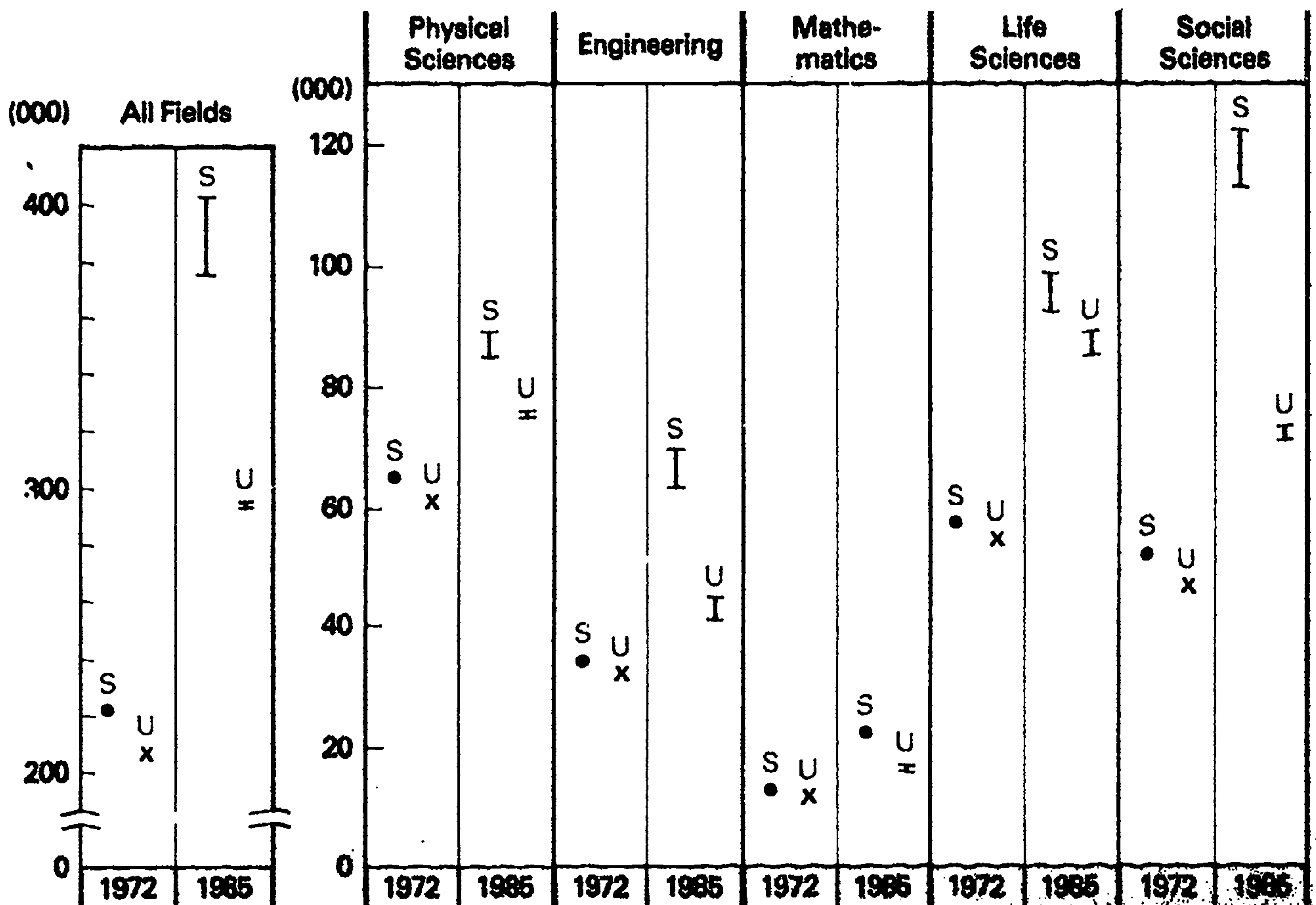
FINDINGS

Chart 1. Supply and utilization ranges of science/engineering doctorates, 1972 and 1985



NOTE: Vertical bars indicate range between Probable and Static Model values of supply and utilization.
SOURCE: National Science Foundation

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Table 1. Summary of science/engineering doctorate labor force and utilization, by field of degree and model: 1972 and 1985

[In thousands]

Item	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
			1972 Estimate			
Labor force	221	65	34	13	57	53
S/E utilization	206	61	32	12	54	47
Non-S/E utilization[1]	15	5	2	1	3	6
S/E utilization as percent of labor force	*93*	*93*	*9[illegible]*	*96*	*95*	*89*
			1985 - Probable Model			
Labor Force	375	85	63	22	92	113
S/E utilization	293	76	45	16	85	71
Non-S/E utilization[1]	82	9	18	6	7	42
S/E utilization as percent of labor force	*78*	*89*	*71*	*73*	*92*	*63*
			1985 - Static Model			
Labor force	402	89	70	22	99	122
S/E utilization	295	75	41	17	89	73
Non-S/E utilization[1]	107	14	29	5	10	49
S/E utilization as percent of labor force	*73*	*84*	*59*	*77*	*90*	*6[illegible]*

[1] Includes unemployed

Note: Detail may not add to totals because of rounding.

Source: National Science Foundation

• The current and projected utiliz
Model) reveal a significant shift fro
to "other S/E" and "non-S/E" activ
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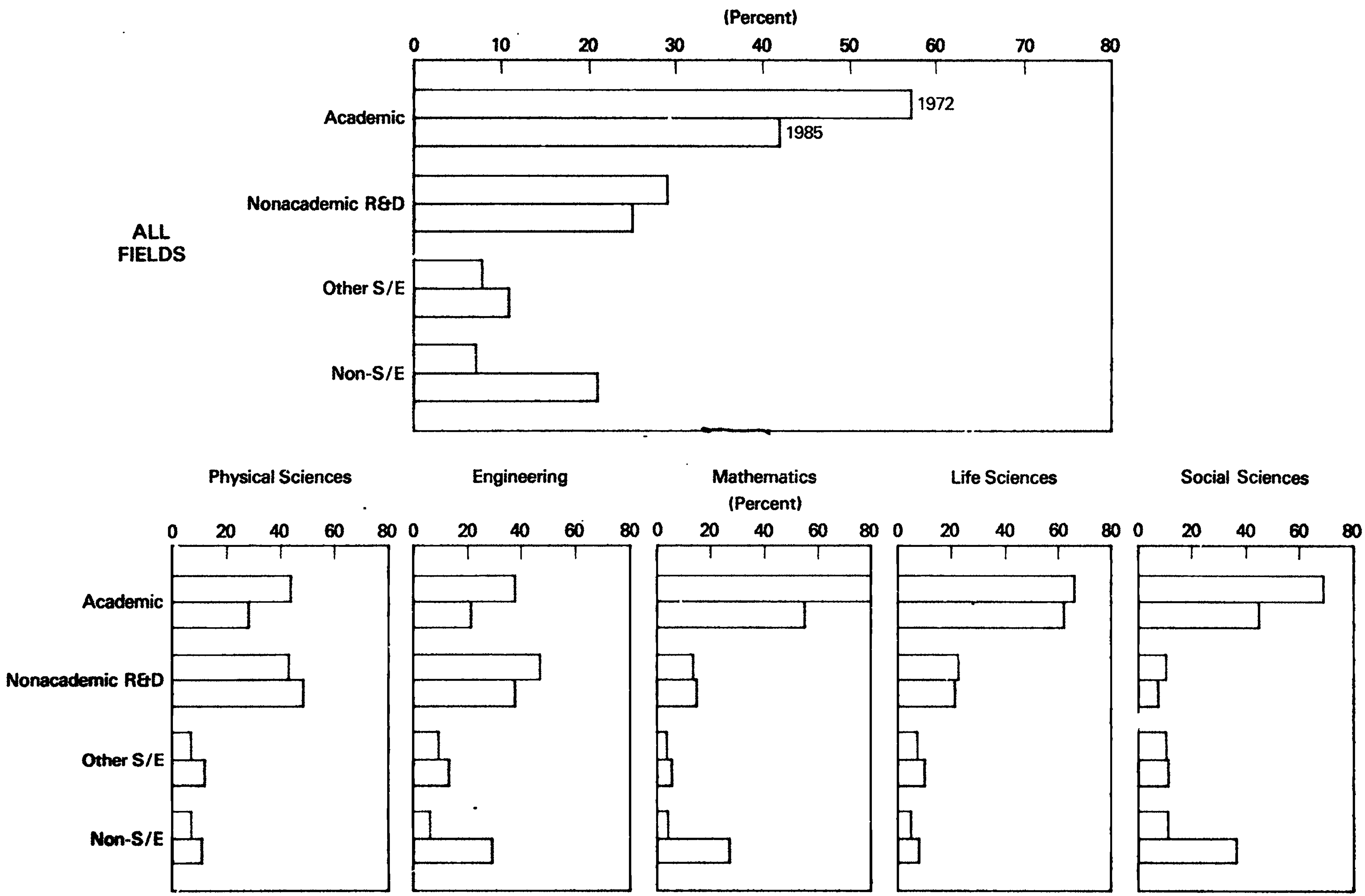
...g	Mathe- matics	Life sciences	Social sciences
Estimate			
	13	57	53
	12	54	47
	1	3	6
	96	*95*	*89*
obable Model			
	22	92	113
	16	85	71
	6	7	42
	73	*92*	*63*
tatic Model			
	22	99	122
	17	89	73
	5	10	49
	77	*90*	*60*

• The current and projected utilizations of S/E doctorates (Probable Model) reveal a significant shift from academic and R&D involvement to "other S/E" and "non-S/E" activities (chart 2). This shift is caused primarily by expected decreases in 4-year college-and-university S/E enrollments, due to demographic and student career choice factors, and expected slow growth in constant dollar R&D funding. Thus, the Probable Model indicates that by 1985 about one-third of the doctorate S/E labor force might be employed neither by institutions of higher education nor engaged in nonacademic research and development. Furthermore, the same model reveals the possibility that over one-fifth of the 1985 doctorate labor force may not be engaged in any S/E activity, compared with less than one-tenth in 1972.

Chart 2. Utilization of science/engineering doctorates, 1972 and 1985 (Probable Model)



SOURCE: National Science Foundation

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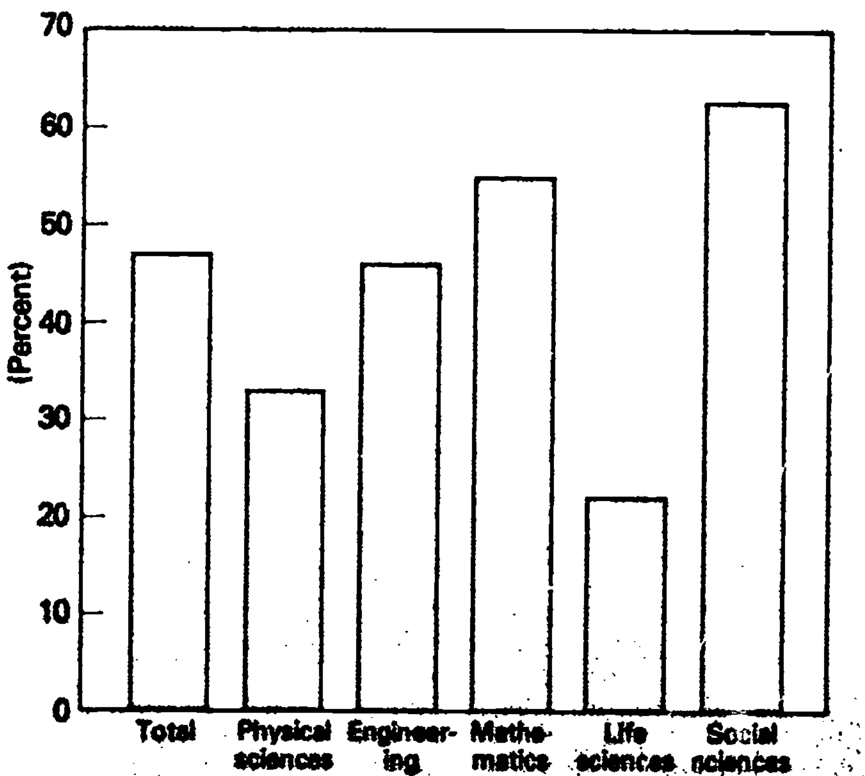
• Chart 3 shows projections of new openings (growth and replacements) in "other S/E" and "non-S/E" activities as a proportion of all new openings expected to be filled by S/E doctorates during the 1972-85 period under the Probable Model. In aggregate, these non-academic, non-R&D openings account for nearly one-half of all new openings, compared to one-seventh of the 1972 doctorate labor force. This shift to nontraditional job opportunities will probably have a more profound effect on new doctorates than on those already in the labor force. Consequently, this expected shift has major educational implications for institutions as well as for students.

Chart 3. Proportion of new openings for science/engineering doctorates in other science/engineering and non-science/engineering activities, 1972-85



SOURCE: National Science Foundation

• The results of these projections ... the anticipated condition of the fu... graduates in the next decade. Or... million college graduates will be en... ties, with 6.8 million leaving the lab... projected that economic growth w... professional jobs and replacements... 6.4 million graduates. This leaves ... entering other employment, many... tivities or in positions similar to th... past

Variations by Field

• The projections of changes in dc... activity vary considerably, with the... employment evident in the physical... an increase in academic utilization i...

• An indicator of imbalance is the p... the difference between the projecte... utilization. In the Probable Model, th... sciences (8 percent) and greatest ir... (table 1). The possible relatively larg... ing doctorates, evolving from th... probably on the high side. Many cur... ing employment indicate a likely s... run. This could lead to a greater... previous nondoctorate positions th...

• The proportion of new job openin... "other S/E" and "non-S/E" activitie... jected to be large in the social scier... the life sciences (12 percent), compa... and mathematical sciences.

[4] Neal H. Rosenthal, "The U S Economy in 1985, P... *Labor Review* (December 1973).

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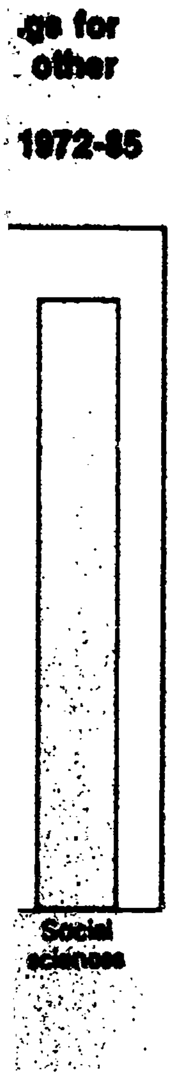
• The results of these projections are an additional manifestation of the anticipated condition of the future labor market for all college graduates in the next decade. One author[2] projects that over 15 million college graduates will be entering the labor force in the seventies, with 6.8 million leaving the labor force. For the same period, it is projected that economic growth will generate less than 5.6 million professional jobs and replacements in these occupations will require 6.4 million graduates. This leaves 3.0 million new college graduates entering other employment, many of them in nonprofessional activities or in positions similar to those filled by nongraduates in the past.



Variations by Field

• The projections of changes in doctorate utilization by type of S/E activity vary considerably, with the most drastic shift from academic employment evident in the physical sciences and engineering, while an increase in academic utilization is anticipated for the life sciences.

• An indicator of imbalance is the projected non-S/E utilization; i.e., the difference between the projected doctorate labor force and S/E utilization. In the Probable Model, this imbalance is smallest in the life sciences (8 percent) and greatest in the social sciences (37 percent) (table 1). The possible relatively large non-S/E utilization of engineering doctorates, evolving from this projection methodology, is probably on the high side. Many current projections of total engineering employment indicate a likely shortage of engineers in the long run. This could lead to a greater use of doctorate engineers in previous nondoctorate positions than is assumed in the projections.

• The proportion of new job openings (growth and replacements) in "other S/E" and "non-S/E" activities for the 1972-85 period is projected to be large in the social sciences (55 percent) and smallest in the life sciences (12 percent), compared to 35 percent for the physical and mathematical sciences.

[2] Neal H Rosenthal. "The U S Economy in 1985. Projected Changes in Occupations," *Monthly Labor Review* (December 1973).

Chapter II. SUMMARY OF FACTORS, METHODS, AND ASSUN

Several explicit and implicit assumptions underlie the supply and utilization in models developed for this study. Essentially, these assumptions are expectations of some continuity with the past, since all supply and utilization models extend or modify past trends and relationships. It is assumed that:

- In both utilization models, work presently being performed by doctorates will, in the future, continue to be carried out by doctorates.
- Mobility within science/e S/E fields will not change limited information exi consistent time series is
- Other factors, such as health of the domestic a necessity for technolog continue along past tren

Table 2. Summary of supply models[1]

Factor	Assumptions/Methods	Rationale	
1. Higher education attainment rates[2]			
a. Static Supply Model	Both halves of 10-year period given equal weight.	Same weight for each 5-year period = 7.3% increase over Probable Model projection of 1985 S/E doctorate labor force.	Chang batior in the
b. Probable Supply Model	Extension of trends of past 10 years, with second half of period weighted doubly. Separate rates calculated for sex and field of study.	Use of 12-year trends with last 5 years weighted doubly = 0.7% and 3.0% increases in physical and social science doctorates awarded over projected period.	Event. in long modif condit
2. Immigration (Both Models)	Based on total S/E immigrants and proportion with doctorates. 1973 level of immigration continued.	10% change in total immigration for 1972-85 period = 0.3% difference in 1985 S/E doctorate labor force.	Projec result tion.
3. Emigration (Both Models)	Based on number of foreign citizens projected to receive doctorates in U.S. Probable Model allows for slight relative increase over Static Model.	10% change in total emigration for 1972-85 period 0.9% difference in 1985 S/E doctorate labor force.	Docto crease motiva by ma U.S. ci
4. Attrition (Both Models)	Death and retirement (D&R) rates for all men in labor force applied to S/E doctorate labor force (by 5-year age groups). Rates remain constant in projected period.	10% change in average attrition rate for 1972-75 period = change of 1.4% in S/E doctorate labor force.	D&R r of strc

[1] See chapter V (pp. 13-18) and appendix A-4 for fuller discussion of supply models.

[2] Includes rates for entry to college, complet completion of doctorate.

)F FACTORS, METHODS, AND ASSUMPTIONS

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nuity with the past, since
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- Mobility within science/engineering (S/E) fields and/or non-S/E fields will not change in the projected period. While some limited information exists about mobility patterns, no consistent time series is available.
- Other factors, such as the continuity of institutions, the health of the domestic and worldwide economies, and the necessity for technological inputs to many activities, will continue along past trends.

Table 2. Summary of supply models[1]

ıods	Rationale	Sensitivity
1 given equal	Same weight for each 5-year period = 7.3% increase over Probable Model projection of 1985 S/E doctorate labor force.	Changes in last 5 years were excessive perturbations and do not represent a basic change in the 10-year trends.
0 years, with ed doubly. sex and	Use of 12-year trends with last 5 years weighted doubly - 0.7% and 3.0% increases in physical and social science doctorates awarded over projected period.	Events of past 5 years made significant changes in long-term trends. Trends of past 10 years modified to reflect anticipated future conditions.
:s and propor- vel of immi-	10% change in total immigration for 1972-85 period - 0.3% difference in 1985 S/E doctorate labor force.	Projected unfavorable market conditions will result in continuing limitations on immigration.
citizens projected Probable Model ase over Static	10% change in total emigration for 1972-85 period - 0.9% difference in 1985 S/E doctorate labor force.	Doctorates awarded to foreign citizens will increase relative to the total because their motivation to seek degrees will not be affected by market conditions as much as those of U.S. citizens.
rates for all S/E doctorate ups). Rates period.	10% change in average attrition rate for 1972-75 period - change of 1.4% in S/E doctorate labor force.	D&R rate for women doctorates = to men because of strong labor market attachment.

ı of supply models

[2] Includes rates for entry to college, completion of baccalaureate, entry to graduate school, and completion of doctorate.

The major factors and related assumptions associated with each of the supply and utilization models are summarized in tables 2 and 3. Also listed are the rationales underlying the assumptions and the sensitivity of the projected supply or utilization to the various assumed

parameters. The sensitivities reflect of projections, given the noted cha variables remaining unchanged. descriptions can be found in chapte

Table 3. Summary of utilization models [1]

Factor	Assumptions/Methods	Rationale	
1. **Faculty in 4-year colleges and universities**			
a. S/E enrollments and S/E student/faculty ratios (Both Models)	Graduate enrollments derived from supply models. Undergraduate enrollments by field based on proportions of baccalaureates by field. Student/faculty ratios derived from faculty workload information from five State systems.	Enrollments consistent with supply models. Student/faculty ratios (weighted for undergraduate and graduate loads) by field held constant in projected period in absence of trend data and expected continuation of financial stress in educational institutions.	10% ch over 19 doctora
b. Enrichment [2] (Both Models)	All openings due to attrition (death and retirement) and growth will be filled by doctorates.	Data from 1969 to 1973 NSF surveys indicate nearly all of openings (D&R, attrition and growth) filled by doctorates.	No enri ratios o in 1985
2. **Faculty in 2-year colleges**			
a. Total enrollments and total student/faculty ratios			
(1) Static Model	Office of Education projections, extended by NSF to 1985. Student/faculty ratios remain at 1972 levels through 1985.	No trend data available.	10% ch period = utilizat
(2) Probable Model	Used same enrollments as in Static Model. Student/faculty ratios projected to decrease by 0.1% per year for 1972-85 period.	Increasing importance of 2-year schools for baccalaureate education will lead to adoption of a greater degree of 4-year educational content and faculty composition in 2-year schools.	
b. Enrichment [2]			
(1) Static Model	Enrichment rate to increase at 6.6% per year, from 7.2% in 1972 to 14.5% in 1985.	Data from 1969 to 1973 NSF surveys indicate this rate of change.	10% ch 1972-85 doctora
(2) Probable Model	Enrichment rate to increase at 9.9% per year, from 7.2% in 1972 to 20.3% in 1985.	Increasing role of 2-year schools in baccalaureate education.	

, associated with each rized in tables 2 and 3. umptions and the sen- the various assumed parameters. The sensitivities reflect the changes in the final outcome of projections, given the noted change in one variable, with all other variables remaining unchanged. More detailed methodological descriptions can be found in chapters V and VI, and in the appendixes.

Table 3. Summary of utilization models [1]

hods	Rationale	Sensitivity
d from supply lments by field calaureates by derived from n from five	Enrollments consistent with supply models. Student-faculty ratios (weighted for undergraduate and graduate loads) by field held constant in projected period in absence of trend data and expected continuation of financial stress in educational institutions.	10% change in overall student/faculty ratio over 1972-85 period = 7% difference in 1985 S/E doctorate utilization.
(death and be filled by	Data from 1969 to 1973 NSF surveys indicate nearly all of openings (D&R, attrition and growth) filled by doctorates.	No enrichment, i.e., openings filled at 1972 ratios of doctorates to total = 18% decrease in in 1985 S/E doctorate utilization.
ns, extended ulty ratios 1985.	No trend data available.	10% change in student/faculty ratios over 1972-85 period = 0.1% difference in 1985 S/E doctorate utilization.
Static Model. ed to de- 972-85	Increasing importance of 2-year schools for baccalaureate education will lead to adoption of a greater degree of 4-year educational content and faculty composition in 2-year schools.	
6.6% per .5% in 1985.	Data from 1969 to 1973 NSF surveys indicate this rate of change.	10% change in rate of enrichment growth over 1972-85 period = 0.1% difference in 1985 S/E doctorate utilization.
9.9% per .3% in 1985.	Increasing role of 2 year schools in baccalaureate education.	

Table 3. Summary of utilization models[1] — Cont'd.

Factor	Assumptions/Methods	Rationale	
3. Nonacademic R&D			
a. R&D expenditures and cost per scientist/engineer (Both Models)	R&D expenditures and cost/scientist or engineer (in constant prices) assumed to increase at rates of 1.4% and 0.6%, respectively.	Federal R&D expenditures expected to continue recent trends. Increases also expected in industry-funded R&D. Cost/professional increase based on past trends.	10% ci over 1 S/E dc increa in 198
b. Enrichment[2]			
(1) Static Model	Enrichment rate to increase at 3% per year, from 13.9% in 1972 to 19.8% in 1985.	Derived data from Industrial Research Institute survey which indicate expected enrichment trends.	10% ch over 1 doctor
(2) Probable Model	Enrichment rate to increase at 5% per year, from 13.9% in 1972 to 25.0% in 1985.	Increased availability of doctorates to allow such growth.	10% ch over 1 utiliza
4. Other S/E employment			
a. Total activity (Both Models)	2.4% average annual rate of growth in total employment of scientists and engineers, based on BLS economic projections	Rate of growth is consistent with overall economic assumptions in NSF models.	10% ci emplo
b. Enrichment[2]			
(1) Static Model	None; doctorates will remain a constant 1.8% of total S/E employment in these activities.	Reflects estimates of current ratios of doctorates to total S/E's. No trend data available.	10% d total S differe
(2) Probable Model	Enrichment rate to increase at 10% per year from 1.8% in 1972 to 6.1% in 1985.	Increased availability of doctorates and continuation of past patterns of upgrading in these circumstances will allow such growth.	10% ch cover doctor

[1] See chapter VI (pp. 19-24) and appendix A-4 for fuller discussion of utilization models.

[2] Enrichment is an increase in the share of doctorates represent of total employment through increases in doctorates replacing nondoctorates leaving because of death or retirement and/or by increases in the share of doctorates hired for new positions.

Table 3. Summary of utilization models [1] – Cont'd.

...lethods	Rationale	Sensitivity
...ost/scientist or ...ces) assumed to and 0.6%,	Federal R&D expenditures expected to continue recent trends Increases also expected in industry-funded R&D. Cost/professional increase based on past trends.	10% change in rate of growth of R&D expenditures over 1972-85 period = 0.6% difference in 1985 S/E doctorate utilization. 10% change in the rate of increase of cost/professional ratio = 0.2% change in 1985 S/E doctorate utilization.
...ase at 3% per ...2 to 19.8% in 1985.	Derived data from Industrial Research Institute survey which indicate expected enrichment trends.	10% change in annual rate of enrichment growth over 1972-85 period = 0.2% difference in 1985 S/E doctorate utilization.
...ase at 5% per ...2 to 25.0% in	Increased availability of doctorates to allow such growth.	10% change in annual rate of enrichment growth over 1972-85 period = 0.5% of 1985 S/E doctorate utilization.
... of growth in ...ntists and ...economic projections	Rate of growth is consistent with overall economic assumptions in NSF models.	10% change in annual growth rate in total S/E employment over 1972-85 period = 0.2% difference
...nain a constant ...yment in these	Reflects estimates of current ratios of doctorates to total S/E's No trend data available.	10% difference in proportion of doctorates to total S/E employment over 1972-85 period = 0.9% difference in 1985 S/E doctorate utilization.
...ase at 10% per ...to 6.1% in 1985.	Increased availability of doctorates and continuation of past patterns of upgrading in these circumstances will allow such growth.	10% change in annual growth rate of this ratio cover 1972-85 period = 0.6% of 1985 S/E doctorate utilization.

...sion of utilization models
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..., of death or retirement and/or by

Chapter III. THE GENERAL ENVIRONMENT FOR PROJECTIONS

A system of manpower projections assumes implicitly or explicitly a set of national environments during the projection period. Several major factors determine the environment for the supply and utilization of science and engineering (S/E) doctorates including: (1) the economic climate of the country; (2) the nature of the higher education system; (3) the working-life patterns of the labor force; and, (4) the position of the United States with respect to other nations, economically, technologically, and otherwise.

Several key economic indicators provide the vital signs of the levels and rates of growth of an economy. These measures provide the foundation upon which the projections of utilization are directly based, and, indirectly, the projections of supply as well. These indicators projected for 1985 are shown in table 4, and are compared with their 1972 counterparts.

The National Economy

It is estimated that nearly $900 million in additional goods and services will be produced in 1985, compared to 1972. Seventy percent of this amount will be the result of increased productivity of the labor force and 30 percent from added workers. Economists such as Edward F. Denison have attributed part of the past growth of the U.S. economy to the increasing quality of the labor force, resulting from increased educational attainment of workers.[3] The expectation of continued growth of the economy is derived in part from the inputs of scientific, engineering, and other technical workers. The continuing increase in demand for doctorate scientists and engineers is an outgrowth of such expectations.

[1] Committee for Economic Development. *Sources of Economic Growth and the Alternatives Before Us*. New York Committee for Economic Development (1962).

Table 4. Basic economic ir science/engineering d utilization projectior

Indicator	197
	(Bill
Gross national product (GNP)	$1,15
Gross private product (GPP)	1,01
	(M
Total civilian labor force	8
Employed	8
Unemployed	[illegible]
	(E
Private manhours	144
GPP per private manhours (productivity)	$7.04

Source: Ronald E Kutscher, "The U.S. Economy ir Employment," *Monthly Labor Review* (Dec. 1973).

L ENVIRONMENT FOR PROJECTIONS

implicitly or explicitly
ion period. Several ma-
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Table 4. Basic economic indicators underlying the science/engineering doctorate supply and utilization projections: 1972 and 1985

Indicator	1972	1985	Average annual percent change 1972-85
	(Billions of 1972 dollars)		
Gross national product (GNP)	$1,155.2	$1,942.5	4.1
Gross private product (GPP)	1,019.7	1,765.6	4.3
	(Millions of persons)		
Total civilian labor force	86.6	105.7	1.5
Employed	81.8	101.5	1.7
Unemployed	4.8	4.2	—
	(Billions of hours)		
Private manhours	144.8	170.9	1.3
	(1972 dollars)		
GPP per private manhours (productivity)	$7.04	$10.34	3.0

Source Ronald E Kutscher, "The U S Economy in 1985, Projections of GNP, Income, Output and Employment," *Monthly Labor Review* (Dec. 1973).

Other Environmental Aspects

These other aspects of the environment are implicit in both the GNP and the manpower supply and utilization projections of this report.

- The institutional framework of the economy will not change significantly within the projected period, and the role of the labor force will follow past trends.

- On the international scene, a detente between the major powers will have been reached by 1985, but continued guarded relationships will not allow significant reductions in defense expenditures.

- Fiscal and monetary policies, combined with socioeconomic policies, will progress toward achieving a balance between full employment and diminished inflation without interfering with the long-term economic growth rate, although mild economic cycles are to be expected.

- All levels of government will continue to deal with a wide variety of domestic problems, with State and local governments playing an increasing role in the operation of economic and social development programs. The role of science and technology is also expected to become more important to the operation of programs dealing with national, regional, and local problems.

- Past trends in education will continue—with 2-year colleges increasing their share of undergraduates—and most graduate school enrollees entering directly or soon after receiving undergraduate degrees. The role of continuing or midcareer education, while expected to grow, is not expected to detract significantly from the traditional undergraduate and graduate education patterns, nor add significantly to the total number of students enrolled in colleges and universities.

Basic Premises Affecting D
and Utilization

Inherent in the projections cor
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EXPANSION/

- A doctorate may still have a rel
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- The doctorate degree constitute
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[4] D. Bailey and C Schotta, "Private and Social R
American Economic Review (March 1972), and
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Basic Premises Affecting Doctorate Supply and Utilization

Inherent in the projections contained in this report are some basic premises that either tend to encourage or discourage the production of and expanded demand for doctorates.

EXPANSIONARY FACTORS

- A doctorate may still have a relative advantage over less educated contemporaries in the same field, even if doctorate starting salaries remain higher than those of others. With an "oversupply" of doctorates, however, their salaries will tend to adjust downward relative to those of nondoctorates.

- The doctorate degree constitutes a "ticket" to a frequently preferred professional or academic life and work style (regardless of economic considerations). This phenomenon is likely to continue.[4] It has been shown that this enticement can have a great impact upon the career and educational investment decisions of students.

- Increased educational requirements are being placed upon many jobs. Over the years the educational prerequisites of jobs increased as job content changed and as secondary and higher education became more universal. In the future, the concept of "appropriate" utilization of S/E doctorates may be broadened even further to include new activities in which their knowledge would be desirable for the management and performance of nonresearch or noneducational activities. Thus, the doctorate degree may become a prerequisite for positions currently being filled by nondoctorates, in part because of the availability of doctorates and in part because of the increasing technical content of the positions.

[4] D. Bailey and C Schotta, "Private and Social Rates of Return to Education of Academicians, *The American Economic Review* (March 1972), and Notes to this article by L. Figa-Talamanca and J. A. Tomaske, *The American Economic Review*, (March 1974).

CONTRACTIVE FACTORS

• In apparent reaction to perceived unemployment problems of scientists and engineers and other factors, such as disenchantment with technology, students at all levels of education—secondary, undergraduate and graduate—in the past few years have been less prone to opt for a major in the physical sciences, mathematics, and engineering than students of the midsixties. It is not known if this disaffection is a phenomenon which will pass as employment opportunities improve and as new societal programs with technological inputs are created, or if it is part of a long-term movement away from these disciplines. Some recent anecdotal evidence indicates that this trend may be reversing itself.

• In the early seventies proportionately fewer college-age persons have been entering college, possibly because of the slowdown of job opportunities for college graduates. Projections of job opportunities indicate a potential surplus of college graduates, in general, in relation to available jobs of the type now being filled by graduates.[5]

• College students will be discouraged from continuing their education to the doctorate level if: (1) the reduced growth (in comparison to the sixties) in the demand for college faculty and researchers continues as expected; and (2) the level of earnings of doctorate degree holders moves toward that of master's and bachelor's degree holders.

[5] Neal H. Rosenthal, *op cit.*

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[6] Ivar Berg, *Education and Jobs: The Great Tr*
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[7] National Science Foundation, Detailed Statistic
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• A decrease in the number of graduate students may necessitate further increases in tuition charges to support university costs. This will tend to hinder the opportunity for education and limit the number of students pursuing a doctorate degree. This factor could be aggravated by additional reductions in direct Federal support of graduate students.

• Some students of the economics of education have come to believe that there may have been an overinvestment in higher education in the past two decades in relation to the numbers and nature of employment opportunities that have become available.[6] Such belief has led to some under- and unemployment of college graduates, especially in many less developed countries (LDC's). It may also have discouraged foreign students who study in industrialized countries from returning to their less developed homelands. Recognition of this oversupply of college graduates in the LDC's may have led to the reductions in the numbers of their citizens sent to schools in the United States. This is reflected in 1973 enrollment data.[7]

It is not expected that any one of the above-mentioned factors or a particular combination of the expanding or contracting factors will prevail, but rather that each set will exert a countervailing force upon the other—each set moderating the potential impact of the other.

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[6] Ivar Berg *Education and Jobs: The Great Training Robbery*. New York: Praeger Publishers (1970). and Special Task Force to the Secretary of Health, Education, and Welfare, *Work in America*. Cambridge. Mass The MIT Press (1973).

[7] National Science Foundation. Detailed Statistical Tables, *Graduate Science Education: Student Support and Postdoctorals. Fall 1973* (NSF 74-318-A) (Washington. D.C. 20550), 1974.

Chapter IV. DOCTORATE SCIENTIST AND ENGINEER UTILIZ

In mid-1972 doctoral science/engineering (S/E) degree holders residing in the United States numbered 229,000. Of these, 221,400 were in the labor force—218,700 employed, and 2,700 were seeking work. The remaining 7,600 were either retired or not seeking work for other reasons.[8]

Table 5 indicates that 93 percent of the doctorates in the S/E labor force were employed in S/E activities, 5.6 percent were engaged in non-S/E activities, and unemployment claimed 1.2 percent. (Comparable unemployment rates in 1972 were 4.7 percent for the total civilian labor force and 1.9 percent for all professional and related workers.)[9] It is tempting to define the 5.6 percent of the doctorate labor force employed in non-S/E-related work as being "under-utilized"; however, economic evidence disputes such an assumption. First, there is no relationship between the unemployment and non-S/E employment by field of doctorate (table 5) and second, the income data from the survey show higher earnings for the "non-S/E-related" workers than for their colleagues in S/E-related employment. Thus, while the very presence of unemployment is an indication that underutilization probably exists, there is no definite measure of its magnitude.

[8] Data in this chapter are based on a survey conducted by the National Research Council (NRC) for NSF They are the results of the responses of individuals who received their doctorate degrees in the school years ending from 1930 to 1972 The survey of doctorates undertaken by NRC for NSF also revealed that some 7,900 persons who had received degrees in fields other than science or engineering indicated they were employed in a S/E field in 1972. These doctorates were omitted from these considerations National Research Council. *Doctoral Scientists and Engineers in the United States. A 1973 Profile.* Washington. D C.. 1974

[9] U S Council of Economic Advisors. *Economic Report of the President*, February 1974. Washington. D C 20402 Supt of Documents. U S Government Printing Office (1974), table C-24, and U S Department of Labor. Bureau of Labor Statistics. *Employment and Earnings* (Nov. 1973). table A-35

As one might expect, a stror doctorate-level employment in th employment of persons with doct ciplines. Table 6 distributes the S/E of degree. In all fields except mathe

Table 5. Labor force and employ doctorates, by fi

Labor force/employment status	Total
Total in population[1]	229.0
Not in labor force[2]	7.6
Total in labor force	221.4
Employed	218.7
In science or engineering	206.2
In nonscience/engineering	12.5
Unemployed	2.7
Total in labor force	100.0
Employed	98.8
In science or engineering	93.1
In nonscience/engineering	5.6
Unemployed (unemployment rate)	1.2

[1] Those not reporting labor force status (3 p among the categories

[2] Retired housewives, etc.

Note: Detail may not add to totals because c

Sources: National Science Foundation and N

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Employment and Earnings (Nov. 1973).

As one might expect, a strong relationship was found between doctorate-level employment in the sciences and engineering and the employment of persons with doctorate degrees in the respective disciplines. Table 6 distributes the S/E jobs filled by doctorates by the field of degree. In all fields except mathematics and the social sciences, less

Table 5. Labor force and employment status of science/engineering doctorates, by field of degree: 1972

Labor force/employment status	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
	In thousands					
Total in population[1]	229.0	67.7	34.5	13.3	59.1	54.4
Not in labor force[2]	7.6	2.4	.5	.4	2.4	1.9
Total in labor force	221.4	65.3	34.0	12.9	56.7	52.5
Employed	218.7	64.3	33.7	12.7	56.1	51.9
In science or engineering	206.2	60.6	32.3	12.4	54.0	46.9
In nonscience/engineering	12 5	3.7	1.4	.3	2.1	5.0
Unemployed	2.7	1.0	.3	.2	.6	.6
	Percent distribution					
Total in labor force	100.0	100.0	100.0	100 0	100.0	100.0
Employed	98.8	98.5	99.1	98.5	98.9	98.9
In science or engineering	93.1	92.8	95.0	96.1	95.2	89.3
In nonscience/engineering	5.6	5.7	4.1	2.3	3.7	9.5
Unemployed (unemployment rate)	1 2	1 5	.9	1.5	1.1	1.1

[1] Those not reporting labor force status (3 percent) have been redistributed proportionately among the categories

[2] Retired, housewives, etc

Note Detail may not add to totals because of rounding.

Sources National Science Foundation and National Research Council.

than 1 percent of the jobs was filled by non-S/E doctorates. In each employment field, except for mathematics, more than 80 percent of the positions were occupied by holders of degrees in the respective fields. In the NSF projections opportunities in these occupations have been equated with those for persons with the respective degrees.

Educational institutions employed 61 percent of S/E doctorates in 1972; however, the proportions varied widely, from 83 percent of the mathematicians to 40 percent of the engineers. Industrial and other business organizations employed 24 percent of all doctorate scientists and engineers, but nearly one-half of the engineers and less than 6 percent of the social scientists. Governments employed about 11 percent of all doctorates, but 6 percent of the mathematicians and 14 percent life scientists (table 7).

Functional activities of these doctorates, given in numbers of individuals "primarily engaged" in each of these activities, were not as clearly determined as other parameters. On this basis, R&D activities in the nonacademic sectors—research, development, and the administration of research and development—accounted for more than 30 percent of all doctorates. This proportion also varied by field—nearly one-half the engineers and physical scientists were primarily engaged in R&D-related activities, while about 11 percent of the social scientists were similarly occupied.

Table 6. Percent distribution of science/engineering doctorates, by field of degree and employment: 1972

Field of degree	Physical scientists	Mathematicians	Engineers	Life scientists	Social scientists
Total	100	100	100	100	100
Physical sciences	90	7	15	7	[1]
Mathematics	[1]	75	2	[1]	[1]
Engineering	4	8	81	1	[1]
Life sciences	5	1	1	88	1
Social sciences	1	3	1	3	81
Subtotal, all sciences	99	93	99	99	89
Nonsciences	1	7	1	1	11

[1] Less than 0.5 percent

Note: Percents may not add to 100 because of rounding.

Sources: National Science Foundation and National Research Council.

Table 7. Science/engineeri[ng] ... activity, and field

Sector	Total	Ph[ysical] sci[entists]
Total	206.2	[illegible]
Academic[1]	125.6	[illegible]
Nonacademic[2]	80.6	[illegible]
Industry	49.5	[illegible]
Government	23.1	
Federal	19.4	
Other government	3.7	
Other[3]	8.0	
Nonacademic activity:		
R&D	63.3	[illegible]
Other[3]	17.3	
Total	100.0	[illegible]
Academic[1]	60.9	
Nonacademic[2]	39.1	[illegible]
Industry	24.0	[illegible]
Government	11.2	1[illegible]
Federal	9.4	1[illegible]
Other government	1.8	
Other[3]	3.9	
Nonacademic activity:		
R&D	30.7	
Other[3]	8.4	

[1] Includes only institutions of higher education

[2] See activity in which engaged below.

[3] Includes those who did not report activity an[d] ...

Note: Detail may not add to totals because of r[ounding] ...

Sources: National Science Foundation and Nat[ional] ...

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1	88	1
1	3	81
;9	99	89
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Table 7. Science/engineering doctorates, by sector, activity, and field of degree: 1972

Sector	Total	Physical sciences	Engi-neering	Mathe-matics	Life sciences	Social sciences
	In thousands					
Total	206.2	60.6	32.3	12.4	54.0	46.9
Academic[1]	125.6	28.5	13.0	10.3	37.3	36.5
Nonacademic[2]	80.6	32.1	19.3	2.1	16.7	10.4
Industry	49.5	24.2	15.0	1.2	6.4	2.7
Government	23.1	7.3	3.4	.7	7.4	4.3
Federal	19.4	6.6	3.1	.6	6.3	2.8
Other government	3.7	.7	.3	.1	1.1	1.5
Other[3]	8.0	.6	.9	.2	2.9	3.4
Nonacademic activity:						
R&D	*63.3*	*27.6*	*16.0*	*1.7*	*12.7*	*5.1*
Other[3]	*17.3*	*4.3*	*3.3*	*.4*	*4.0*	*5.3*
	Percent distribution					
Total	100.0	100.0	100.0	100.0	100.0	100.0
Academic[1]	60.9	47.0	40.2	83.1	69.1	77.8
Nonacademic[2]	39.1	53.0	59.8	16.9	30.9	22.2
Industry	24.0	39.9	46.4	9.7	11.9	5.8
Government	11.2	12.0	10.5	5.6	13.7	9.2
Federal	9.4	10.9	9.6	4.8	11.7	6.0
Other government	1.8	1.2	.9	.8	2.0	3.2
Other[3]	3.9	1.0	2.8	1.6	5.4	7.2
Nonacademic activity:						
R&D	*30.7*	*45.9*	*49.5*	*13.7*	*23.5*	*10.9*
Other	*8.4*	*7.1*	*10.2*	*3.2*	*7.4*	*11.3*

[1] Includes only institutions of higher education.
[2] See activity in which engaged below.
[3] Includes those who did not report activity and/or industry.
Note Detail may not add to totals because of rounding.
Sources. National Science Foundation and National Research Council

Chapter V. PROJECTED SUPPLY

Two supply models, both reflecting trends of the sixties and early seventies are utilized for these projections. These models incorporate the principal components that contribute to future doctorate pools—the 1972 doctorate labor force, new graduates, immigrants, emigrants, and attrition resulting from death and retirement. Because of lack of data, no account was taken of those science and engineering (S/E) doctorates who cease to be active in S/E activities or of non-S/E doctorates who carry out S/E activities at the doctorate level. This implies that the relative net effect of these opposing flows will remain constant over the projection period.

Doctorate Awards

The major projected increases in the doctorate supply will come from newly trained doctorates. The degree model used, as shown in chart 4, consists of a four-stage (matrix) process. The first stage relates college entrants to the population reaching the age of college entrance; the second, bachelor's-degree recipients to the appropriate cohorts of college entry: the third, graduate school entries to the appropriate bachelor's-degree cohorts, and the last, doctorate-degree recipients to the appropriate cohorts of graduate school entries. The last three stages are derived by field of science/engineering and by sex. By necessity, the first stage was calculated by sex only since freshmen generally cannot be identified with a specific field of study. Projections in each stage are the results of regression equations of patterns of the last 10-year period for which data were available with double weight assigned to the trends of the second-half of the decade in the case of the Probable Model projections, and single weight in the Static Model projections. This methodology was selected because marked changes in long-term trends have occurred during the 1967-72 period and it is expected that these trends will continue though in a somewhat less pronounced fashion. The rationale for this expectation is based on projected supply-utilization imbalances that arise out of the current projections regardless of whether double or single weights are applied to the trends of the last five years. Actual and projected Probable Model rates of progress at separate stages of the higher education process are shown further in chart 5.

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Matrices were developed on t
following parameters: baccalaure
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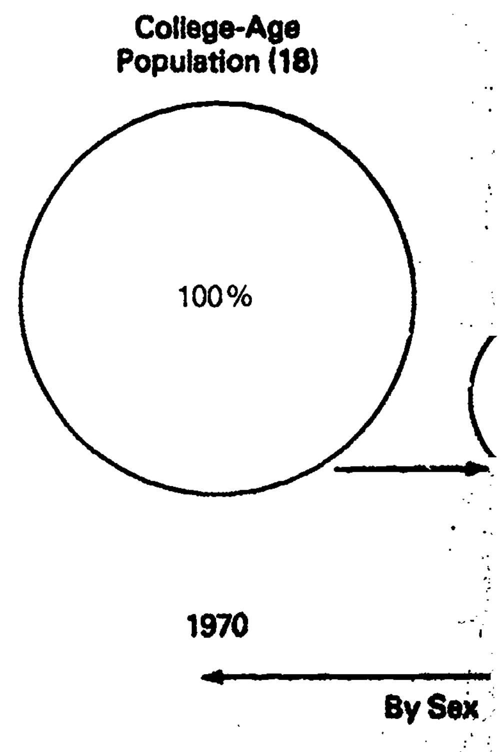
Chart 4. Development - doctorate suppl



SOURCE: National Science Foundation

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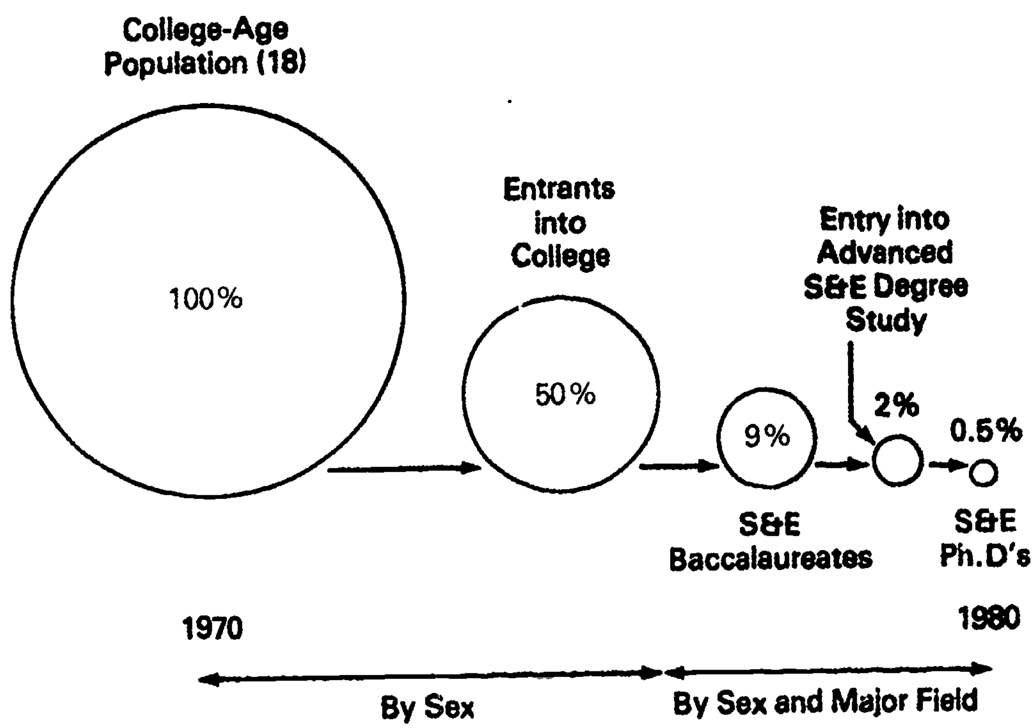
Thus, both projections imply that the factors responsible for the recent significant changes in student flows will be operating during the entire projection period, but that student responses in selection of educational goals will not be as severe as in recent years. The latter assumption is based on the belief that the changes of the early seventies probably represented initial extreme reactions to suddenly changing labor markets. Thus, the basic difference between the Probable and Static Models is the degree of relaxation, in some cases, of the rather sharp recent downward trends.

Matrices were developed on the basis of fixed-time spreads of the following parameters: baccalaureate attainment of a single year's freshmen cohort; entry into graduate school after baccalaureate award; and Ph.D. award after entry into graduate school. It is implicitly assum-

Chart 4. Development of new science/engineering doctorate supply (Probable Model)



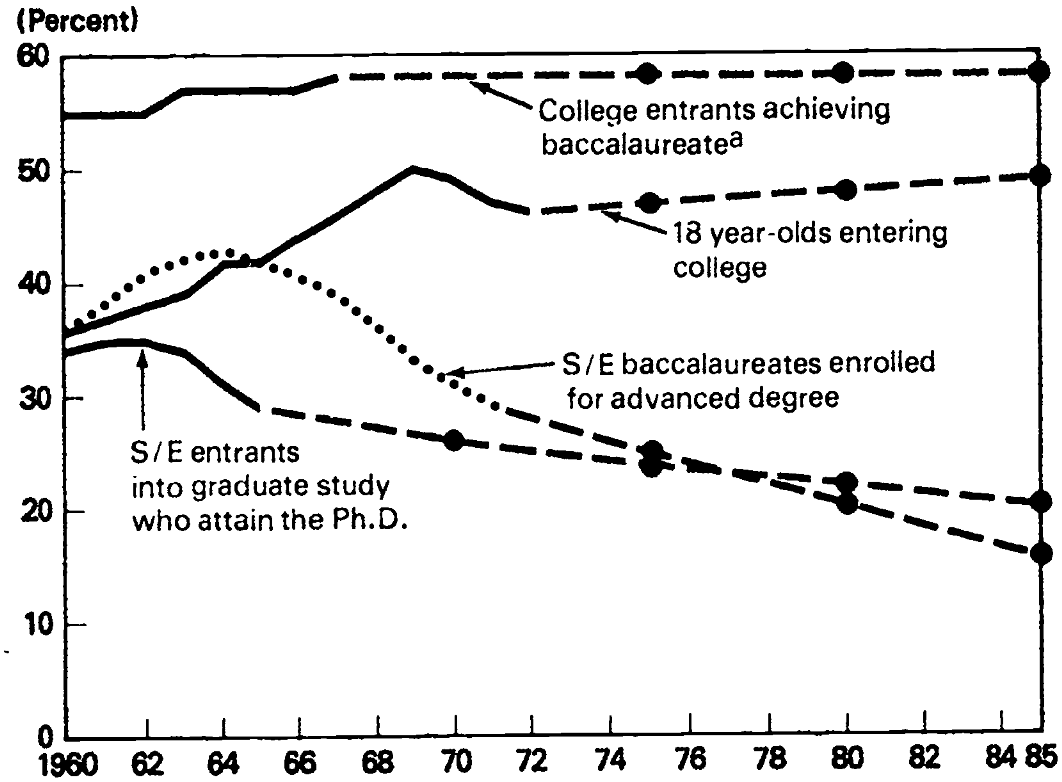
SOURCE: National Science Foundation

ed in these projections that field switching (from bachelor's field to graduate fields) will continue as it has in the past and that foreign undergraduate and graduate students will follow generally the same patterns as American students.

The new doctorate-degree recipient models also yield projections of baccalaureates and total graduate enrollments as byproducts, which were used to project academic utilization of doctorates (chapter VI). The doctorate and enrollment projections are shown in chart 6.

Although there is no specific feedback from the utilization results, the Probable Projection Model may be considered more closely responsive to market conditions than the Static Model.

Chart 5. Estimated rates of progress in four stages of higher education, 1960-85

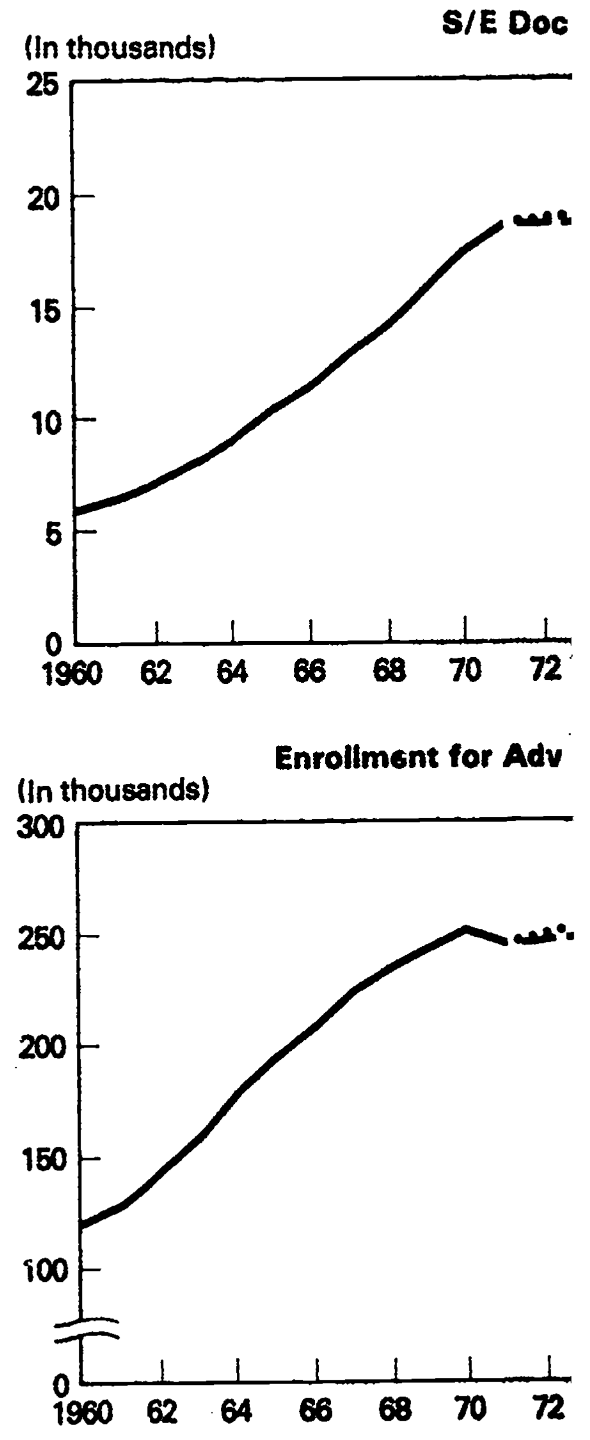


[a]Or first professional degree.

Note: S/E = science/engineering

SOURCE: National Science Foundation

Chart 6. Science/enginee science/engineering enrollment



SOURCE: National Science Foundation and Office

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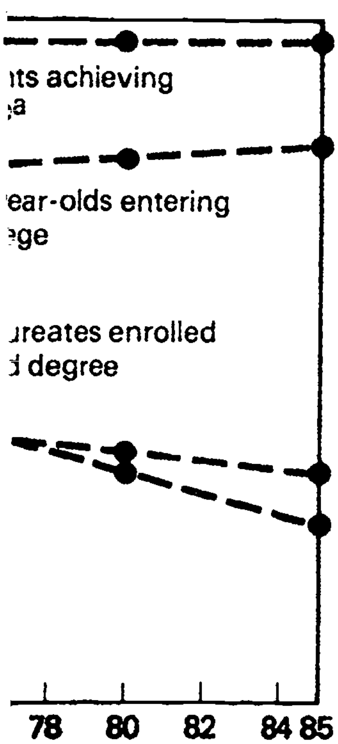
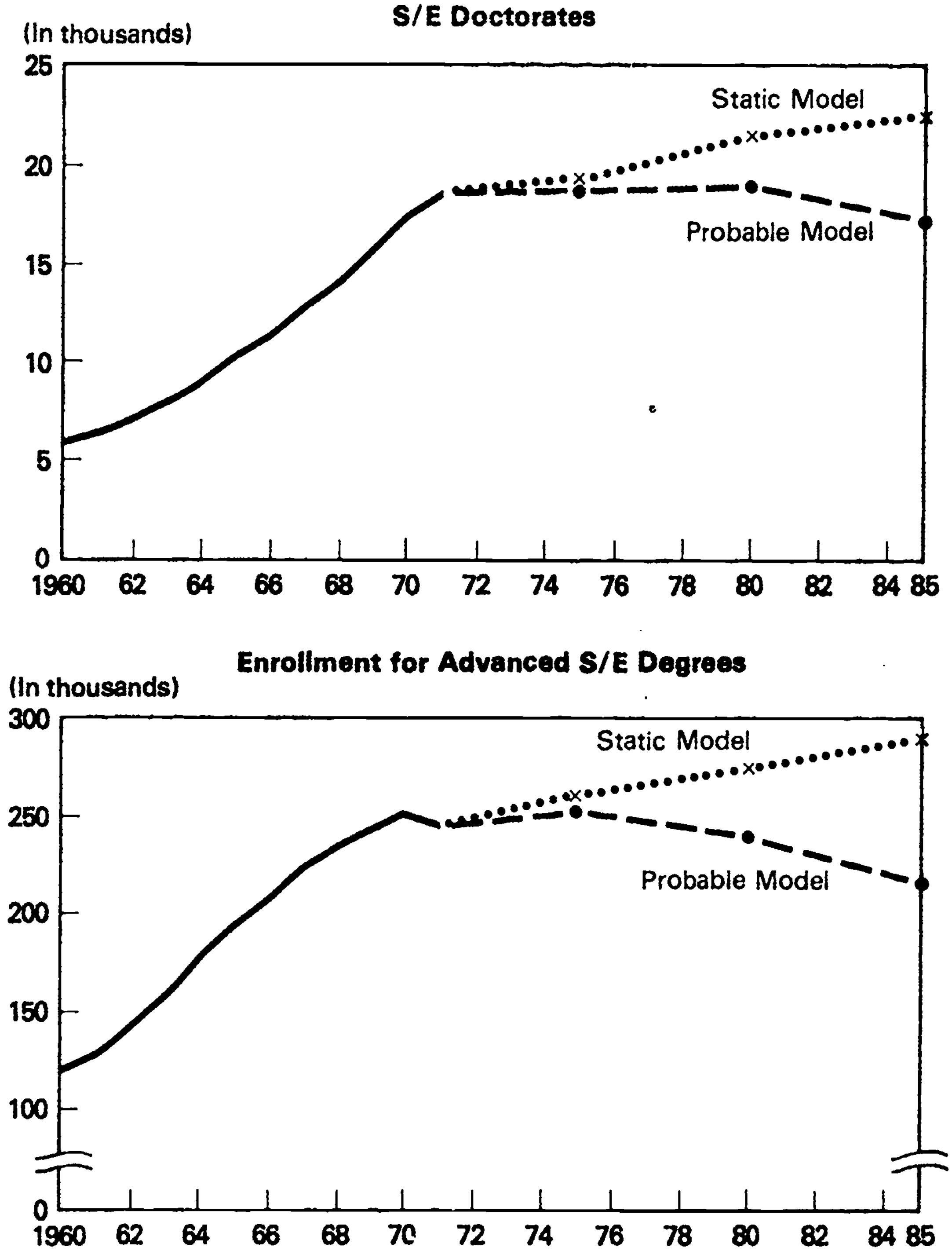


Chart 6. Science/engineering doctorates and total science/engineering enrollment for advanced degrees, 1960-85



SOURCE: National Science Foundation and Office of Education

Immigration of Doctorates

In the past, foreign-trained scientists have played a significant role in scientific activity in the United States, and, until the rapid growth of U.S. graduate education after World War II, these scientists represented a significant share of the doctorate labor force. Foreign-trained doctorates (some of whom are U.S. citizens) are expected to continue to migrate to the United States in spite of potentially unfavorable employment conditions for doctorates in this country. The reasons for this continued migration are (1) the relatively good employment opportunities here, and (2) relatively poor economic and/or political conditions in the immigrants' own countries. These factors may serve to mitigate the potential dampening effect of the employment situation of the United States.

Immigration of doctorates was projected at the estimated 1973 annual level, which reflects earlier changes in immigration regulations, limiting the number of scientists and engineers formerly allowed to enter to fill positions for which U.S. workers were not available. These projections were made by field of science/engineering, and account for a small portion (7 percent) of the net additions of the doctorate labor force. Both supply models contain the same immigration assumptions and levels as shown in table 8.

Emigration of Doctorates

In the 1972-73 academic year about 12 percent of the new S/E doctorate recipients indicated that they intended to find employment in other countries. More than one-fifth of all new S/E doctorates were foreign citizens. In the Probable Projection Model—although fewer are expected to emigrate than in the Static Model—a slightly larger share of all graduates are expected both to be foreign citizens and to emigrate. It is rationalized here that an unfavorable labor market in the United States will deter some foreign students from pursuing graduate education, but not to the same extent as U.S. citizens (table 8).

These projections imply that the United States is expected to continue its role as an educator for other nations, especially those with less developed economic and education systems. The projections also imply, however, that the United State
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foreigners. In 1973 more than 4(
science/engineering were enrolled
fifths of these coming from the de
represented about one of every si

Although alternative scenario
students could readily be develope
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Attrition

Both models assume the same
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Labor Statistics.[10] No expectation
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Both supply models incorpo
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[10] Howard N. Fullerton, Jr., "A New Type of W
(July 1972).

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States is expected to con-
, especially those with less
s. The projections also im-

ply, however, that the United States will not be devoting a greater portion of its graduate education resources for the purpose of educating foreigners. In 1973 more than 40,000 foreign graduate students in science/engineering were enrolled in U.S. universities, with nearly four-fifths of these coming from the developing countries. These students represented about one of every six students in these discipline areas.

Although alternative scenarios regarding the number of foreign students could readily be developed, this area is subject to a great deal of uncertainty. If the opportunities for the appropriate utilization of doctorates continue to deteriorate in the United States relative to opportunities in other countries, a greater degree of emigration could be expected in the future. On the other hand, as the educational systems of other industrialized countries develop further, they will be competing with U.S. universities for students, with a resulting decrease in enrollments of foreign students in this country. In addition, it has been noted that some less developed countries have a surplus of highly trained workers. Also, both U.S. assistance to foreign students and the funds of the student's countries show signs of decreasing, thus withdrawing the major sources of support of students from less developed nations in U.S. universities. If this situation continues, enrollments of foreign students may decline.

Attrition

Both models assume the same amount of attrition—65,000 during the 1973-85 period reflecting a 1.5-percent annual rate (table 8). It was assumed that attrition from the labor force would result only from deaths and retirements and at the rate for all men in the labor force as estimated in the tables of working life prepared by the U.S. Bureau of Labor Statistics.[10] No expectation of a greater degree of early or late retirements are incorporated in the calculations. Also, women doctorates were assumed to exhibit the same working life patterns as men, without spending a portion of their working years raising a family.

Both supply models incorporate the same attrition projection because almost all of the attrition in the projection period is from existing stock of doctorates rather than new awardees.

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[10] Howard N Fullerton, Jr., "A New Type of Working Life Table For Men," *Monthly Labor Review* (July 1972)

Table 8. Science/engineering doctorate labor force, by field of degree and model: 1972-85

[In thousands]

Component	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
	Probable Supply Model					
1972 Labor Force	221.4	65.3	34.0	12.9	56.7	52.5
1973-79 graduates	150.5	27.9	26.5	9.4	37.9	48.8
Net migration	−12.7	−1.1	−1.4	−.8	−5.5	−3.9
Immigration	7 1	2.4	1.8	.5	1.2	1.2
Emigration	−19.8	−3.5	−3.2	−1.3	−6.7	−5.1
Attrition	−37.2	−10.6	−4.7	−1.7	−10.5	−9 7
1980 Labor Force	321.9	81.5	54.4	19.7	78.6	87.7
1980-84 graduates	89.3	11.9	13.8	3.9	24.5	35.1
Net migration	−8.7	−.6	−.9	−.6	−3.7	−3.0
Immigration	4 4	1.5	1 1	.3	.8	.7
Emigration	−13.1	−2.1	−2.0	−.9	−4.4	−3.7
Attrition	−27.7	−7.7	−4.0	−1.4	−7.3	−7.2
1985 Labor Force	374.9	85.2	63.3	21.6	92.1	112.7
	Static Supply Model					
1972 Labor Force	221.4	65.3	34.0	12.9	56.7	52.5
1973-79 graduates	160.2	29.3	29.2	9.5	40.6	51.6
Net migration	−13.9	−1.2	−1.6	−.8	−6.0	−4.2
Immigration	7.1	2.4	1 8	.5	1.2	1.2
Emigration	−21 0	−3.6	−3.4	−1.3	−7.2	−5 4
Attrition	−37.2	−10.6	−4.7	−1.7	−10.5	−9.7
1980 Labor Force	330.5	82.7	57.0	19.8	80.8	90.2
1980-84 graduates	110.1	15.1	17.7	4.5	29.9	42.8
Net migration	−10.8	−.8	−1.0	−.6	−4.7	−3.8
Immigration	4 4	1.5	1 1	.3	.8	.7
Emigration	−15.2	−2.3	−2.1	−.9	−5.4	−4.5
Attrition	−27.7	−7.7	−4.0	−1.4	−7.3	−7.2
1985 Labor Force	402.1	89.4	69.6	22.3	98.7	122.0

Note: Detail may not add to totals because of rounding.
Source. National Science Foundation.

Supply Projections

THE PROBABL

This model generates 375,000 dc
by 1985—69 percent more than the
percent annual rate of growth of docto
growth rate projected for the total U.S
The 240,000 new U.S. graduates and
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153,000 doctorates over the 1972 ba.

Table 9 shows that physical scier
the Probable Model, with a net gain of
by 1985 to the 65,300 in the 1972 lab-
social scientists, showing a 6-percen
by 1985 to the 52,500 in the 1972 la
growth hover close to the average fc

" Denis F. Johnston, "The U S Economy in 19
Monthly Labor Review (December 1973).

rate labor force, 1972-85

ngi-ering	Mathe-matics	Life sciences	Social sciences
le Supply Model			
4.0	12.9	56 7	52.5
6.5	9.4	37 9	48.8
1.4	− 8	−5 5	−3.9
1.8	.5	1 2	1 2
3.2	−1.3	−6.7	−5.1
4.7	−1.7	−10.5	−9 7
4.4	19.7	78.6	87 7
3.8	3.9	24.5	35 1
−.9	−.6	−3.7	−3.0
1.1	.3	8	7
2.0	−.9	−4.4	−3.7
4.0	−1.4	−7.3	−7.2
3.3	21.6	92.1	112.7
Supply Model			
.0	12 9	56.7	52.5
.2	9.5	40.6	51.6
6	− 8	−6.0	−4.2
.8	.5	1.2	1.2
.4	−1.3	−7.2	−5 4
.7	−1 7	−10.5	−9.7
.0	19 8	80.8	90.2
.7	4.5	29 9	42.8
.0	−.6	−4 7	−3.8
.1	3	8	7
.1	− 9	−5 4	−4.5
.0	−1.4	−7.3	−7.2
.6	22.3	98 7	122 0

Supply Projections

THE PROBABLE MODEL

This model generates 375,000 doctorate scientists and engineers by 1985—69 percent more than the pool in 1972. This implies a 4-percent annual rate of growth of doctorate supply—more than twice the growth rate projected for the total U.S. labor force in the same period.[11] The 240,000 new U.S. graduates and 11,000 immigrants, less 65,000 expected to retire or die, and 33,000 emigrants result in a net change of 153,000 doctorates over the 1972 base (table 8).

Table 9 shows that physical scientists exhibit the slowest growth in the Probable Model, with a net gain of 2 percent annually, adding 20,000 by 1985 to the 65,300 in the 1972 labor force. At the other extreme are social scientists, showing a 6-percent yearly growth rate, adding 60,000 by 1985 to the 52,500 in the 1972 labor force. The other three fields' growth hover close to the average for all S/E doctorates—4 percent.

[11] Denis F Johnston, "The U S Economy in 1985. Population and Labor Force Projection," *Monthly Labor Review* (December 1973)

THE STATIC MODEL

This model produces 402,000 S/E doctorates by 1985, nearly 82 percent more than in 1972, an average annual change of 4.7 percent over the 13-year period (table 8). The net change amounts to 181,000; of this number, 270,000 result from new graduates and 11,000 from immigrants, less the 36,000 emigrants and 65,000 leaving the labor force. The number of new graduates is 30,600 greater (13 percent) than in the Probable Model projection. This represents virtually the entire difference between the two supply models. The rates of growth of the individual fields in the Static Model are all higher than in the Probable Model (table 9). The fields also fall in about the same ranking of growth in the Static as the Probable Model, with physical sciences the slowest growing and social sciences the fastest. The labor force of doctorate social scientists and engineers more than doubles in the projected 13-year period, while doctorate physical scientists grow by about one-third.

It should be emphasized here that both these supply models are dependent upon past trends and do not explicitly reflect the utilization projections presented elsewhere in this report. These supply models, however, have not ignored the utilization trends entirely. Many of the recent career decisions made by students, which were undoubtedly influenced by the probability of low utilization in relation to prospective supply, have been projected into the future, especially in the Probable Model (table 8). The Probable Model produces 11 percent fewer awards of doctorate degrees than the Static Model in the 1973-85 period, resulting in a 7-percent smaller labor force during the same period.

Table 9. Projected percent ch
doctorate labor force, by mod

Model	Total	F s
1972-85 net change ÷ 1972 labor force	69.3	
Average annual rate of net change	4.1	
1972-85 net change ÷ 1972 labor force	81.6	
Average annual rate of net change	4.7	

Source. National Science Foundation.

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ring the same period.

Table 9. Projected percent changes in science/engineering doctorate labor force, by model and field of degree: 1972-85

Model	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
			Probable Model			
1972-85 net change ÷ 1972 labor force	69.3	30.5	86.2	67.4	62.3	114.5
Average annual rate of net change	4.1	2.1	4.9	4.0	3.8	6.0
			Static Model			
1972-85 net change ÷ 1972 labor force	81.6	36.9	104.7	72.9	74.1	132.4
Average annual rate of net change	4.7	2.4	5.7	4.3	4.4	6.7

Source: National Science Foundation

The Effect of Market Factors

It is evident from existing information that student choices for or against careers in science/engineering are affected by many factors. Some of these are nonpecuniary, such as: prestige, style of living, work environment, social attitudes towards science/engineering, etc. Other nonpecuniary factors may be influenced by external considerations, such as the elimination of draft deferments to college students.

Nonpecuniary factors affecting career choices are difficult to project. Fortunately, in recent times they have produced sufficient changes during relatively short periods—three to four years—that projections of past recent trends are likely to take appropriate account of similar effects in the future. This is not to say that a single relatively unpredictable major event such as the military draft or Sputnik could not have a major impact on student choices. For projection purposes, however, such events fall into the same unpredictable category as wars or major economic depressions and no projection can take them into account.

A second important group of factors covers pecuniary aspects such as starting salaries, life-time earnings, the current status of the job market, and last, but not least, projections of future job markets. This last group is frequently given the generic descriptor of "market factors." The market factors are somewhat more predictable in that they are inherently definable in any set of projected supply-utilization calculations. Because of this, most manpower experts are in agreement that every possible effort should be made in projections to consider the effect of these market factors. Having reached this consensus, however, implementation of such market factor methodologies turns out to be quite difficult.

In the current NSF projections, market, as well as nonpecuniary factors, have been taken implicitly into consideration in the Probable Model through the use of a methodology which places major emphasis on the trends of the last five years. This period encompasses most of the changes in attitudes toward science and, most of the major alterations of the job markets. Furthermore, recent enrollment and Ph.D. production figures have reflected the impact of these changes. By using this trend-type of projection methodology, it is essentially assumed that the same factors will be in force during the projection period. In the case of the market factors, this is borne out by the results of the projections in this report, which show a continuation of an imbalance oriented towards an excessive supply.

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would adversely affect decisions
graduate S/E curriculums. Appendix

There was, however, one importa
tion of such a feedback loop; namely,
were available. One of these comes fr
was essentially full employment of S/
1970 period when the market for doct
with the existence of only two data po
the degree of nonlinearity of the fee
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an imbalance oriented

This implicit incorporation of market factor effects could, and should, be improved through use of a recursive market model which would incorporate specific annual market imbalance effects on students' field of study choices in the same year. This would reflect the way most students seem to operate, even though this type of behavior does not take properly into consideration the lag time between current decisions and the actual time when these students would be first exposed to the job market—at least four to five years hence. Efforts were made during the development of the current projections to incorporate computations based on such a model. Specifically, it was assumed that a weakening of the labor market for doctorate scientists and engineers would adversely affect decisions of S/E baccalaureates to enter graduate S/E curriculums. Appendix A-3 shows details of the model.

There was, however, one important limitation to the actual application of such a feedback loop; namely, that only two different data points were available. One of these comes from the 1964-69 period when there was essentially full employment of S/E doctorates, the other covers the 1970 period when the market for doctorates was less strong. Obviously, with the existence of only two data points, it is impossible to determine the degree of nonlinearity of the feedback loop. This, and some experimental calculations which showed the feedback to be quite sensitive to the degree of nonlinearity, made it clear that it was not feasible to use the feedback calculations at this time in actual projections. Thus, it is possible only to describe how the planned approach could be used in future projection computations when more data points are available.

Chapter VI. PROJECTED UTILIZATION

The major professional activities of doctorate scientists and engineers are academic employment (encompassing teaching, research, and administration); nonacademic research and development; other science and engineering (S/E)-related work; and non-S/E-related activity (including unemployment).

Two sets of utilization projections are contained in this report: the Static Model—which is designed to reflect current patterns and recent trends of the employment of doctorates in relation to such parameters as total employment in each activity sector, R&D funding, enrollments, etc.; and the Probable Model—which incorporates recognition of the likely future labor market conditions for all scientists and engineers, and doctorates in particular. In both models, where relevant, the proportion of doctorates among newly-hired scientists and engineers is increased because the ample supply of doctorates in relation to prospective traditional demands for their services is likely to create such patterns of hiring. This process is termed "enrichment"—the replacement of nondoctorates with doctorates in positions resulting from growth and replacement needs.[12]

In this chapter each of the major factors influencing employment trends in the three types of activities are discussed, with reference to both total employment and the employment of persons with doctorate degrees. Occupation and the degree-field of workers have been equated in the base year (1972) data and in the projections to make the utilization definitions conform to the definition in the supply models which project degrees by field. This convention should not be construed to mean that no field-switching is anticipated, or that rigid tests of the educational qualifications for any occupation will be established. Licensure, as for some health professions and certain craftsmen, is not anticipated in the utilization models. It is assumed, however, that the doctorate degree will become increasingly a prerequisite for teaching and research in institutions of higher education. Also, nonacademic R&D employers are likely to seek persons with doctorates more than they have in the past. This proce throughout the economy as each has had more education than its affected primarily those jobs for w degrees below the level of doctor Henceforth, with graduate degre educational standards for certain S the availability of persons who h already evident from recent data future, this effect is likely to be esp non-R&D sector of S/E employme

The Academic Sector

Three major variables influenc of doctorates—the number of stud and the proportion of faculty oper

The number of students, in tur ulation (18-21), the percent likely to of the bachelor's-degree recipients careers in graduate school in S/E c to 21-year-old population to 1985 (indicates a peaking of 16.9 million in 1972, then a drop to 15 million by in 1972.[14] College and university er in 1979 at about 7.1 million (abo 1972),[15] and then decline. Chart 7 the college-age population enrolle continues to increase—approach 1979 enrollments would fall (appe

[12] Consistent with the attrition calculations previously discussed, replacement needs are only those created by death and retirement

[13] Only institutions of higher education ar

[14] U.S. Bureau of the Census, unpublishe

[15] U.S. Office of Education, *Projections o* D.C. 20402: Supt. of Documents, U.S. Govern.

TILIZATION

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they have in the past. This process of enrichment has taken place throughout the economy as each generation entering the labor force has had more education than its predecessors. In the past, this has affected primarily those jobs for which secondary school and college degrees below the level of doctorate became prerequisites for entry. Henceforth, with graduate degrees becoming more commonplace, educational standards for certain S/E positions are likely to respond to the availability of persons who have earned these degrees. This is already evident from recent data on academic employment. In the future, this effect is likely to be especially relevant in the nonacademic, non-R&D sector of S/E employment.

The Academic Sector

Three major variables influence the size of academic employment[13] of doctorates—the number of students, the ratio of students to faculty, and the proportion of faculty openings filled by doctorates.

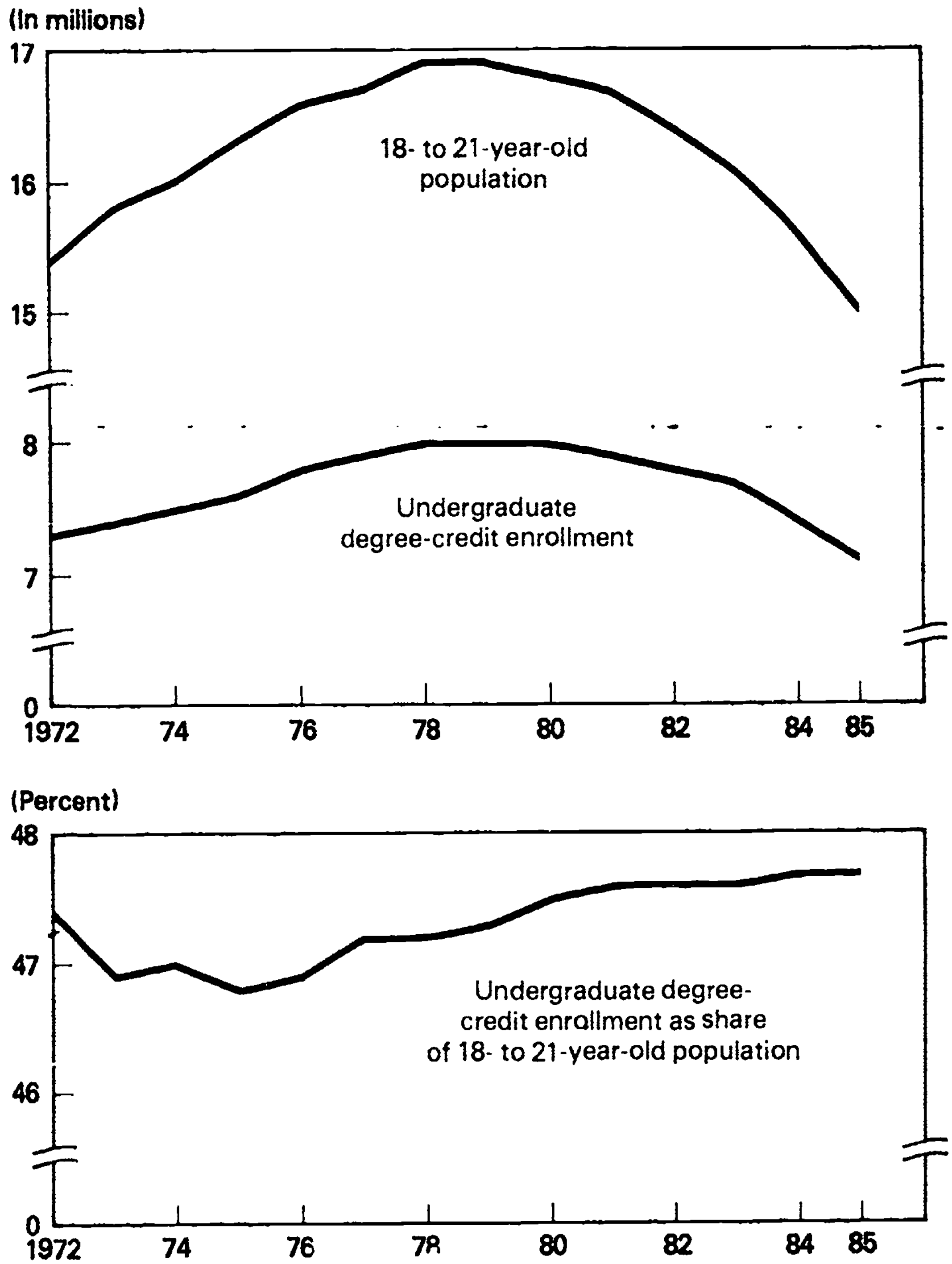
The number of students, in turn, is related to the college-age population (18-21), the percent likely to enroll in college, and the proportion of the bachelor's-degree recipients electing to continue their academic careers in graduate school in S/E curriculums. The projection of the 18- to 21-year-old population to 1985 (all of whom have already been born) indicates a peaking of 16.9 million in 1979, about 1.5 million more than in 1972, then a drop to 15 million by 1985, almost half a million less than in 1972.[14] College and university enrollments are expected also to peak in 1979 at about 7.1 million (about 600,000 more than estimates for 1972),[15] and then decline. Chart 7 indicates that even if the percent of the college-age population enrolled for undergraduate credit in college continues to increase—approaching 48 percent of the group—after 1979 enrollments would fall (appendix table A-5)

[13] Only institutions of higher education are considered here.

[14] U S Bureau of the Census, unpublished estimates

[15] U S. Office of Education, *Projections of Educational Statistics to 1982-83*. (Washington, D C. 20402. Supt of Documents. U S Government Printing Office), 1974 and NSF estimates.

Chart 7. Projections of college-age population and enrollment, 1972-85



SOURCE: Bureau of the Census, Office of Education and National Science Foundation

Appendix table A-10 summari- enrollment projections by fields, and service these enrollments. Becau. dergraduate enrollments by field, it w dergraduates enrolled in a given yea field's share of bachelor's degrees a level enrollments by field are avai necessary.

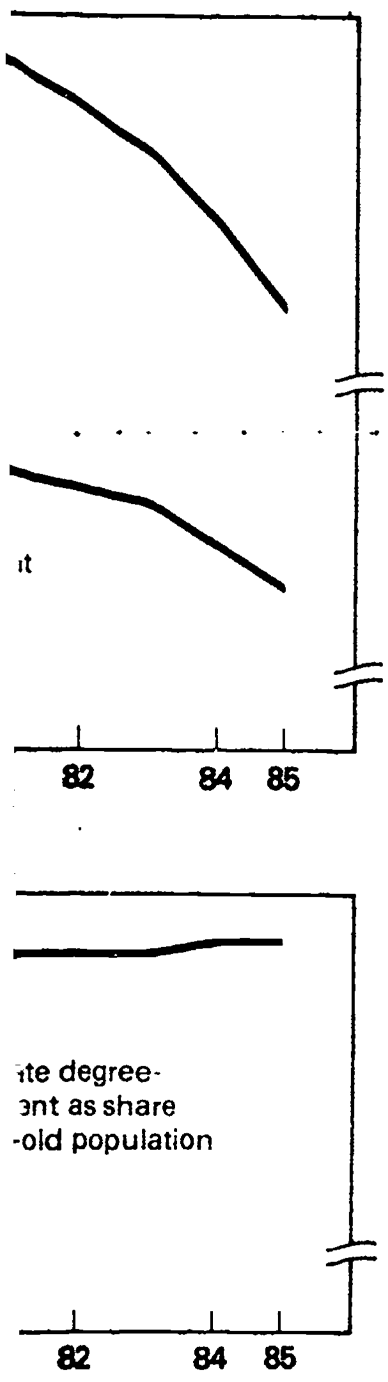
The ratio of students to faculty projected period at the last known dergraduates and graduate studen student : faculty ratios were made c survey of five State college and univ total numbers of students and facu Differences in these student : facult the undergraduate level, result prima (teaching of students not majoring current logic may prescribe an incre faculty in the future—in response straints of institutions—no conclusi the data now at hand. If one believes increase, however, these employme

The ratios of enrichment (replac torates in new hires) were projected 73 period (2-year colleges and the re separately). Since analyses of 196 colleges and universities indicate th faculty positions were filled by dc assumed that all of the growth and r these institutions will be filled by dc Some anecdotal evidence in 1974 in ing the number of teaching assistar doctorates. Extensive use of this openings for doctorates, but coulc students. Such a procedure, howeve jections.

The Probable Model projects lo in 4-year colleges and universities t

--- Colorado Commission on Higher Educatic Colo (1973). The five State systems surveyed were as

-age population
2-85



nal Science Foundation

Appendix table A-10 summarizes undergraduate and graduate enrollment projections by fields, and the associated faculty required to service these enrollments. Because of the lack of data on undergraduate enrollments by field, it was assumed that the number of undergraduates enrolled in a given year in each field is proportional to the field's share of bachelor's degrees awarded in that year. At the graduate level enrollments by field are available, thus this exercise was unnecessary.

The ratio of students to faculty was held constant throughout the projected period at the last known rates for each field, and for undergraduates and graduate students separately. Estimates of these student : faculty ratios were made on the basis of ratios reported in a survey of five State college and university systems[16] normalized to the total numbers of students and faculty estimated for the same years. Differences in these student : faculty ratios among fields, especially at the undergraduate level, result primarily from variations in service loads (teaching of students not majoring in the covered fields). Although current logic may prescribe an increase in the number of students per faculty in the future—in response to rising costs and financial constraints of institutions—no conclusive trends can be ascertained from the data now at hand. If one believes that the student : faculty ratios will increase, however, these employment projections would be too high.

The ratios of enrichment (replacement of nondoctorates with doctorates in new hires) were projected on the basis of trends of the 1969-73 period (2-year colleges and the remaining institutions were treated separately). Since analyses of 1969-73 employment data of 4-year colleges and universities indicate that in net terms essentially all new faculty positions were filled by doctorates, both utilization models assumed that all of the growth and replacement of faculty positions in these institutions will be filled by doctorates in each of the S/E fields. Some anecdotal evidence in 1974 indicates that universities are reducing the number of teaching assistants in favor of employment of new doctorates. Extensive use of this mechanism would create more openings for doctorates, but could reduce the number of graduate students. Such a procedure, however, was not incorporated in the projections.

The Probable Model projects lower academic doctorate utilization in 4-year colleges and universities than the Static Model because the

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[16] Colorado Commission on Higher Education, *1973 Faculty Workload Workbook*, Denver Colo (1973) The five State systems surveyed were California, Colorado, Illinois, Florida, and Texas

Probable Supply Model projects fewer undergraduate and graduate students. Table 10 outlines the differences in the enrollment projections, and total and doctorate faculty needs in 4-year colleges and universities. (Further details are contained in appendix table A-10).

Between 1969 and 1973 the estimated enrichment rate growth in 2-year colleges averaged 6.6 percent per year for S/E faculties.[17] This rate was continued and compounded through the projection period in the Static Utilization Model. In the Probable Utilization Model the enrichment growth rate was increased by 50 percent (to 9.9 percent annually) and compounded to 1985. This sector accounts for few doctorates, and the total difference in the employment level by 1985 is only 400 between the Probable and Static Utilization patterns.

In the 1972-85 period the total academic sector in the Probable Model is projected to grow more slowly than the other sectors, dropping from 61 percent of all S/E doctorates in 1972 to 54 percent by 1985. In the Static Model the share is projected to rise to 64 percent by 1980, but return to 61 percent by 1985.

[17] National Science Foundation. *Resources for Scientific Activities at Universities and Colleges* for 1969 (NSF 70-16) and 1971 (NSF 72-315) (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office). 1969 and 1973.

Table 10. Projections of total science/engineering enrollments[1] and total and doctorate faculty,[2] by field of degree and model: 1972 and 1985

[In thousands]

Item	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
			1972-73			
Enrollments	1.940	169	327	199	369	876
Total faculty[2]	247	32	23	19	105	67
Doctorate faculty[2]	123	28	13	10	37	36
			1984-85 Probable Model			
Enrollments	1.814	118	231	182	346	937
Total faculty	229	23	16	18	102	70
Doctorate faculty	153	23	13	12	55	49
			1984-85 Static Model			
Enrollments	2.013	135	261	204	380	1.032
Total faculty	261	28	19	21	115	79
Doctorate faculty	177	28	13	14	65	57

[1] Undergraduate and graduate

In 4-year colleges and universities.

[2] Developed from NSF surveys

Source National Science Foundation

Nonacademic Research an

The second type of traditional industrial, governmental, and nonp largest sector of employment for er pected to employ more than one-h of the projected period. The level dent on the availability of R&D fur around Federal Government and in report, industrial R&D funding has activity in key R&D-performing in the Federal Government on p technological input; for example, transportation, and energy produc

R&D expenditures were projec nual rate (in constant dollar values creases total R&D expenditures fr 1972 prices) by 1985. Allowing f percent annual rate of change of th employment of R&D scientists an 508,000 to 560,000. Nonacademic r increase from $25.1 billion to $29. employment in this sector from period. Appendix table A-9 presen penditures and associated employn tors of the economy.

In these projections, doctorate employment in nonacademic resea cent in 1972 to 18.4 percent, or 19.3 of compound enrichment growths num, respectively, in the Static and enrichment assumption is based or operations of industrial firms cond assumption represents a larger en greater expected availability of doc 1985 between 91,000 and 95,00 employed in nonacademic researc

[18] NSF estimates: see appendix table A-9, bas of R&D Funding." *Technological Forecasting an* Science Foundation, *R&D Projections—1980 an*

[19] National Science Foundation, *National Pa the United States*, various editions. (Washington ment Printing Office.)

[20] Industrial Research Institute. *Utilization of dustrial Research*. (New York, 1973.)

ergraduate and graduate in the enrollment projec- n 4-year colleges and uni- ›pendix table A-10).

richment rate growth in 2- ɔr S/E faculties.' 'This rate e projection period in the ization Model the enrich- t (to 9.9 percent annually) its for few doctorates, and ; 1985 is only 400 between

ic sector in the Probable ie other sectors, dropping to 54 percent by 1985. In to 64 percent by 1980; but

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neering enrollments[1]
ge and model: 1972 and 1985

ngi- ering	Mathe- matics	Life sciences	Social sciences
1972-73			
27	199	369	876
23	19	105	67
13	10	37	36
Probable Model			
31	182	346	937
16	18	102	70
13	12	55	49
,5 Static Model			
31	204	380	1,032
19	21	115	79
13	14	65	57

Nonacademic Research and Development

The second type of traditional employment for S/E doctorates is in industrial, governmental, and nonprofit R&D activities. It represents the largest sector of employment for engineering doctorates and is also expected to employ more than one-half the physical scientists at the end of the projected period. The level of total R&D employment is dependent on the availability of R&D funds which, in turn, revolves closely around Federal Government and industrial goals and priorities. For this report, industrial R&D funding has been tied to projections of economic activity in key R&D-performing industries and the funds expended by the Federal Government on programs with large amounts of technological input; for example, space exploration, defense, mass transportation, and energy production and conservation.

R&D expenditures were projected to increase at a 1.4-percent annual rate (in constant-dollar values) between 1972 and 1985.[18] This increases total R&D expenditures from $29.1 billion to $34.7 billion (in 1972 prices) by 1985. Allowing for continuation of an average 0.7-percent annual rate of change of the cost per worker[19] raises the total employment of R&D scientists and engineers in the economy from 508,000 to 560,000. Nonacademic R&D expenditures are projected to increase from $25.1 billion to $29.8 billion (in 1972 prices), and S/E employment in this sector from 447,000 to 493,000 in the 1972-85 period. Appendix table A-9 presents a summary of projected R&D expenditures and associated employment by major R&D-performing sectors of the economy.

In these projections, doctorates increase their proportion of total employment in nonacademic research and development from 14.2 percent in 1972 to 18.4 percent, or 19.3 percent, as a result of assumptions of compound enrichment growths of 3 percent and 5 percent per annum, respectively, in the Static and Probable Models. The Static Model enrichment assumption is based on the results of a survey of research operations of industrial firms conducted in 1972.[20] The Probable Model assumption represents a larger enrichment rate increase because of greater expected availability of doctorate scientists and engineers. By 1985 between 91,000 and 95,000 doctorates are expected to be employed in nonacademic research and development.

[18] NSF estimates, see appendix table A-9, based on Charles E. Falk, "Dynamics and Forecasts of R&D Funding" *Technological Forecasting and Social Change* 6 (1974), 171-189 and National Science Foundation, *R&D Projections—1980 and 1985* (in preparation).

[19] National Science Foundation, *National Patterns of R&D Resources, Funds & Manpower in the United States*, various editions (Washington, D.C. 20402: Supt of Documents, U.S. Government Printing Office.)

[20] Industrial Research Institute, *Utilization of and Demand for Engineers and Scientists in Industrial Research*. (New York, 1973.)

Table 11. Science/engineering employment of science/engineering doctorates, by activity, field of degree and model: 1972, 1980, and 1985

Year activity	In thousands: Total	Physical sciences	Engi-neering	Mathe-matics	Life sciences	Social sciences	Perc: Total	Physical sciences	Eng neeri
1972									
Total S E employment	206	61	32	12	54	47	100	100	100
Academic[1]	126	29	13	10	37	37	61	47	40
Nonacademic R&D	63	28	16	2	13	5	31	46	49
Other science engineering	17	4	3	([2])	4	5	8	7	10
					Probable Utilization Model				
1980									
Total S E employment	263	76	36	15	77	54	100	100	100
Academic	158	29	13	12	55	49	60	41	35
Nonacademic R&D	78	34	20	2	15	6	30	49	52
Other science engineering	27	7	5	1	6	8	10	10	14
1985									
Total S E employment	293	76	45	16	85	71	100	100	100
Academic[1]	157	24	13	12	57	51	54	32	29
Nonacademic R&D	95	42	24	3	19	8	32	55	54
Other science engineering	41	10	8	1	9	12	14	13	17
					Static Utilization Model				
1980									
Total S E employment	265	68	37	16	80	65	100	100	100
Academic[1]	169	29	13	13	60	53	64	43	36
Nonacademic R&D	75	33	19	2	15	6	28	49	53
Other science engineering	21	5	4	1	5	6	8	8	11
1985									
Total S E employment	295	75	41	17	89	73	100	100	100
Academic[1]	181	29	14	15	66	58	61	39	33
Nonacademic R&D	91	40	23	2	18	7	31	53	56
Other science engineering	24	6	5	1	6	7	8	8	11

[1] In institutions of higher education
[2] Less than 0 5

Note Detail may not not add to totals because of rounding
Source National Science Foundation.

Science/engineering employment of science/engineering doctorates, by activity, field of degree and model: 1972, 1980, and 1985

In thousands					Percent distribution					
Physical sciences	Engi-neering	Mathe-matics	Life sciences	Social sciences	Total	Physical sciences	Engi-neering	Mathe-matics	Life sciences	Social sciences
61	32	12	54	47	100	100	100	100	100	100
29	13	10	37	37	61	47	40	83	69	78
28	16	2	13	5	31	46	49	14	23	11
4	3	( )	4	5	8	7	10	3	7	11
Probable Utilization Model										
70	38	15	77	64	100	100	100	100	100	100
29	13	12	55	49	60	41	35	82	72	77
34	20	2	15	6	30	49	52	14	20	10
7	5	1	6	8	10	10	14	4	8	13
76	45	16	85	71	100	100	100	100	100	100
24	13	12	57	51	54	32	29	79	67	72
42	24	3	19	8	32	55	54	16	22	11
10	8	1	9	12	14	13	17	6	11	17
Static Utilization Model										
68	37	16	80	65	100	100	100	100	100	100
29	13	13	60	53	64	43	36	84	75	81
33	19	2	15	6	28	49	53	13	19	9
5	4	1	5	6	8	8	11	3	6	10
75	41	17	89	73	100	100	100	100	100	100
29	14	15	66	58	61	39	33	83	74	80
40	23	2	18	7	31	53	56	14	20	10
6	5	1	6	7	8	8	11	3	6	10

Other S/E Activities

The final type of S/E utilization of doctorates is the group of activities not associated with research and development or academia. Most scientists and engineers are currently employed in such activities, but relatively few doctorates. Nearly one million scientists and engineers were carrying out these activities (such as production control, consulting, marketing, and quality control) in 1972; among them were 17,300 S/E doctorates. Utilization of doctorates in this nonacademic-other group was projected by applying annual growth rates to the 1972 base equivalent to those developed by the Bureau of Labor Statistics (BLS)[21] for its projection of total 1985 S/E employment. Further information on projections in these activities may be found in appendix table A-10. In the Probable Utilization Model, on the basis of a compounded enrichment rate of 10 percent per year, these activities are projected to employ about 41,100 doctorates by 1985. As a result, the doctorate share of employment in these activities would rise to about 3 percent in 1985, compared to only 1.8 percent in 1972. If no enrichment were to occur, as assumed in the Static Utilization Model, only 24,000 would be employed in these types of activities by 1985.

Overall Projections

Total utilization projections of S/E doctorates resulting from the use of the Static and Probable Models are very similar; however, the changes in their functional components are quite different. Tables 11 and 12 show that in the Static Model academic utilization increases more rapidly than in the Probable Model. On the other hand, the situation is reversed with respect to nonacademic research and development and other S/E activities, where growth is more pronounced in the Probable Model. Thus, these two these overall utilization projectior

These tables also show that ir rates of employment growth in the r development and other science/er academic activities in the Probab tribution of individual fields withir employment was assumed to rem. fields in these types of activities academic employment, however, tions of enrollments by field. Thus, differ.

[21] U.S. Department of Labor, Bureau of Labor Statistics, *The U.S. Economy in 1985*, Bulletin 1809 (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office.)

Table 12. Average annual perce employment of science/engine of degree and

Activity	Total
Total science/engineering	2.7
Academic[1]	1.7
Nonacademic R&D	3.2
Other science/engineering	6.7
Total science/engineering	2.8
Academic[1]	2.9
Nonacademic R&D	2.8
Other science/engineering	2.5

[1] In institutions of higher education.

Source: National Science Foundation.

orates is the group of ac-
evelopment or academia.
mployed in such activities,
e million scientists and
(such as production con-
trol) in 1972; among them
of doctorates in this
y applying annual growth
eveloped by the Bureau of
otal 1985 S/E employment.
activities may be found in
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quite different. Tables 11
emic utilization increases
the other hand, the situa-
research and development
more pronounced in the

The U S. Economy in 1985. Bulletin
overnment Printing Office)

Probable Model. Thus, these two countervailing trends tend to bring these overall utilization projections to similar magnitudes.

These tables also show that in each field (except life sciences) the rates of employment growth in the nonacademic sectors—research and development and other science/engineering—are faster than those of academic activities in the Probable Utilization Model. Since the distribution of individual fields within nonacademic R&D and other S/E employment was assumed to remain constant, the growth rates of all fields in these types of activities are identical. Field distribution of academic employment, however, was based on independent projections of enrollments by field. Thus, the growth rates by field and activity differ.

Table 12. Average annual percent change in science/engineering employment of science/engineering doctorates, by activity, field of degree and model: 1972-85

Activity	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
			Probable Utilization Model			
Total science engineering	2.7	1.8	2.6	1.9	3.6	3.2
Academic	1.7	−1.3	.1	1.4	3.3	2.6
Nonacademic R&D	3.2	3.2	3.2	3.2	3.2	3.2
Other science engineering	6.7	6.7	6.7	6.7	6.7	6.7
			Static Utilization Model			
Total science engineering	2.8	1.6	1.8	2.6	4.0	3.4
Academic	2.9	2	4	2.7	4.5	3.7
Nonacademic R&D	2.8	2.8	2.8	2.8	2.8	2.8
Other science engineering	2.5	2.5	2.5	2.5	2.5	2.5

In institutions of higher education

Source National Science Foundation

Table 13 summarizes the 1972-85 S/E doctorate employment picture in terms of the components contributing to new job openings. As can be seen, the changes are significantly different in each model. Thus, in the Probable Model, academic employment represents about 44 percent of the net new demand—all resulting from enrichment expectations and replacement needs. In the Static Model the academic sector accounts for 60 percent of new openings. In the Probable Model more than a fifth of new demand occurs in the other S/E sector, with 30,000 new openings; in the Static Model, with 11,000 openings, it accounts for 8 percent of new demand. Note that these estimates exclude non-S/E employment. Further detail can be found in appendix table A-11.

While enrichment rates have be fields of science, it should be pointe difference in engineering. Current o jections all seem to indicate a p engineers over the entire projectio academic employers to use a much thus increasing engineering doctora the numbers indicated here.

Table 13. Incremental employment of science/engineering doctorates, by activity, component and model: 1972-85

Activity	In thousands: Total requirements	Growth	Enrichment	Replacement[1]	Percent distribution: Total requirements	Growth	Enrichment	Rep m
	Probable Utilization Model							
Total	141	1	85	54	100	(2)	100	1
Academic	62	−12	44	30	44	(2)	51	
Nonacademic R&D	49	7	25	17	35	(2)	30	
Other science/engineering	30	7	17	7	22	(2)	19	
	Static Utilization Model							
Total	141	17	72	52	100	100	100	1
Academic	85	4	51	29	60	25	71	
Nonacademic R&D	45	7	21	17	32	37	29	
Other Science/engineering	11	7	—	5	8	37	—	

[1] Replacement of doctorates only.
[2] Not applicable
Note Detail may not add to totals because of rounding
Source National Science Foundation.

ɔctorate employment pic-
to new job openings. As
different in each model.
ɔyment represents about
ing from enrichment ex-
atic Model the academic
s. In the Probable Model
e other S/E sector, with
h 11,000 openings, it ac-
these estimates exclude
ound in appendix table

While enrichment rates have been assumed to be identical for all fields of science, it should be pointed out that there may be a significant difference in engineering. Current overall engineering manpower projections all seem to indicate a probable significant shortage of engineers over the entire projection period. This may induce non-academic employers to use a much greater enrichment for engineers, thus increasing engineering doctorate employment considerably over the numbers indicated here.

13. Incremental employment of science/engineering doctorates, by activity, component and model: 1972-85

	In thousands				Percent distribution			
	Total require-ments	Growth	Enrich-ment	Replace-ment[1]	Total require-ments	Growth	Enrich-ment	Replace-ment[1]
	Probable Utilization Model							
....	141	1	85	54	100	([2])	100	100
....	62	−12	44	30	44	([2])	51	55
....	49	7	25	17	35	([2])	30	32
....	30	7	17	7	22	([2])	19	13
	Static Utilization Model							
....	141	17	72	52	100	100	100	100
....	85	4	51	29	60	25	71	57
....	45	7	21	17	32	37	29	34
g	11	7	—	5	8	37	—	9

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o totals because of rounding
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APPENDIXES

A. Technical Notes

B. Selected Related Publications

APPENDIX A

Technical Notes

STATISTIC.

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APPENDIX A

echnical Notes

STATISTICAL TABLES

CHARTS

1. Comparisons with Previous NSF Studies of Supply and Utilization of Science/Engineering Doctorates

Tables A-1 through A-3 detail the differences between this report and its two predecessors—*Science & Engineering Doctorate Supply & Utilization*, the 1969 and 1971 reports, respectively. Each table compares the results for 1980, the terminal year of the prior projections.

The total science and engineering (S/E) utilization projection for 1980 declined from the 1969 study to the 1971 analysis, and declined even further in the current report. While the labor force projection declined from the first to the second report, the current report's 1980 labor force remains within the range of the 1971 projections. Comparisons of projections for each of the fields show a variety of differences between the 1971 and the current report. The current range of labor force projections for physical sciences and engineering falls midway between the high and low 1971 projections; that for mathematics, below the range for 1971; life sciences, near the top of the 1971 range; and social sciences, slightly above the 1971 range (table A-1).

Doctorate utilization in 1980 is now projected to be lower, or at the lower part of the range projected in 1971, except for the life sciences. The current utilization projections for physical sciences and mathematics are considerably below the levels projected in 1971. See table A-2 and chart A-1.

Table A-2 also details the sources of the differences in the utilization projections. Comparing the high utilization model of the 1971 study with the Probable Model of this study, the 32,000 fewer employment opportunities in the current model result from 28,000 less in other science/engineering and 7,000 less in the academic sector. Comparing the Probable Model in the current study with the high 1969 projections, the 38,000 fewer opportunities in the current study results from 10,000 less in other science/engineering, 9,000 fewer nonacademic research and development, and 19,000 fewer in the academic sector.

The large differences in other S/E utilization stems from a revised approach now used to project doctorate employment in these activities, namely, relating doctorate employment to total S/E employment in the activity. The previous reports assumed that doctorate employment in other science/engineering would be a function of the total doctorate labor force. Thus, as the supply of new doctorates in[c]
S/E jobs would also increase. The preser[...]
torates to overall economic activity, espe[...]
ing employment of all scientists and en[...]

The differences in R&D and acade[...]
reports result from changed assumptio[...]
funding and the number of students expe[...]
Table A-3 outlines the underlying assu[...]
economic activity, R&D expenditures, [...]
enrollments in the school year 1979-80.

Table A-1. Comparisons of 1980 p[...] doctorate labor force [...] NSF studies, by [...]

[Labor force in[...]

Report publication date	Total	Ph[...] sc[...]
Current[1]	322-331	8[...]
1971	315-336	[illegible]
1969[2]	352	[illegible]

[1] Probable Model shown first. Where both proj[...]
[2] One labor force projection.
N.A.—not available
Source: National Science Foundation

ous NSF Studies
zation of
Doctorates

ıces between this report and its
ctorate *Supply & Utilization*, the
e compares the results for 1980,

ı utilization projection for 1980
sis, and declined even further in
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orce remains within the range of
ons for each of the fields show a
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jections; that for mathematics,
the top of the 1971 range; and
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cted to be lower, or at the lower
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A-2 and chart A-1.

ifferences in the utilization pro-
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ne 38,000 fewer opportunities in
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ation stems from a revised ap-
nent in these activities, namely,
mployment in the activity. The
rate employment in other
the total doctorate labor force.

Thus, as the supply of new doctorates increased, doctorates employed in other S/E jobs would also increase. The present approach ties opportunities for doctorates to overall economic activity, especially those areas most directly affecting employment of all scientists and engineers.

The differences in R&D and academic employment among the various reports result from changed assumptions about the projected level of R&D funding and the number of students expected to be enrolled in college by 1980. Table A-3 outlines the underlying assumptions of the three reports—overall economic activity, R&D expenditures, S/E doctorate awards and graduate enrollments in the school year 1979-80.

Table A-1. Comparisons of 1980 projections of science/engineering doctorate labor force produced in different NSF studies, by field of degree

[Labor force in thousands]

Report publication date	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
Current[1]	322-331	81-83	54-57	20	79-81	88-90
1971	315-336	80-84	54-58	23-25	76-81	81-87
1969[2]	352	N.A.	N.A.	N.A.	N.A.	N.A.

[1] Probable Model shown first. Where both projections are the same, one number is entered.
[2] One labor force projection.
N.A.—not available.
Source: National Science Foundation

Table A-2. Comparisons of 1980 projections of science/engineering doctorate utilization produced in different NSF studies, by activity and field of degree

[In thousands]

Activity	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
			Current Study[1]			
Total	263-265	70-68	38-37	15-16	77-80	64-65
Academic	158-169	29	13	12-13	55-60	49-53
Nonacademic R&D	78-75	34-33	20-19	2	15	6
Other science/engineering	27-21	7-5	5-4	1	6-5	8-6
			1971 Study[2]			
Total	297-270	88-76	42-37	22-21	74-70	71-66
Academic	165-164	29-28	16	18	53-52	49-48
Nonacademic R&D	77-66	39-34	15-13	1	14-12	9-7
Other science/engineering	55-40	20-14	11-8	3-2	7-6	13-10
			1969 Study[2]			
Total	301-277	N.A.	N.A.	N.A.	N.A.	N.A.
Academic	177-149	N.A.	N.A.	N.A.	N.A.	N.A.
Nonacademic R&D	87-90	N.A.	N.A.	N.A.	N.A.	N.A.
Other science/engineering	37-38	N.A.	N.A.	N.A.	N.A.	N.A.

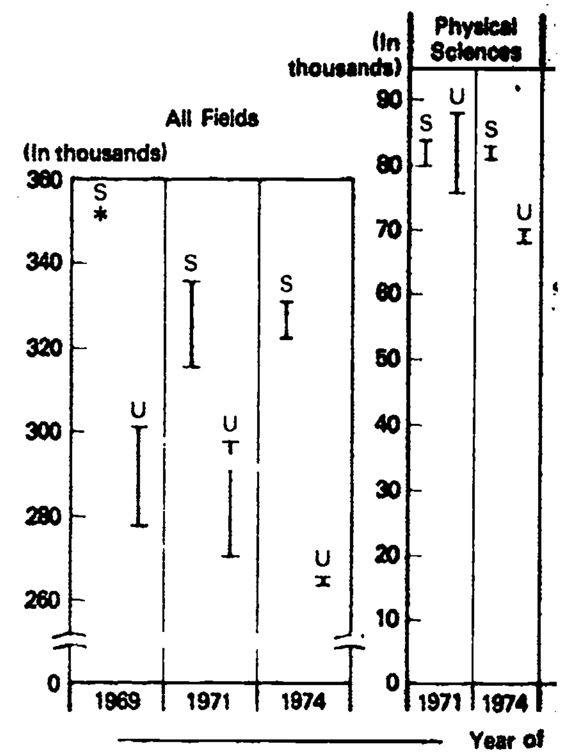
[1] Probable Model shown first. Where both projections are the same, one number is entered.
[2] High model shown first.
N.A. Not available.
Source: National Science Foundation

Table A-3. Comparisons of 1980 projections of science/engineering doctorate supply and contributing components produced by different NSF studies

Item	Current report	1971 report	1969 report	Percent difference between current and— 1971 report	Percent difference between current and— 1969 report
		Billions of dollars			
Gross national product	$1,658.0	$1,698.0	$1,689.0	2.4	1.9
Expenditures for R&D					
Low	31.1	45.8	36.2	47.3	16.4
High		50.9	42.4	63.7	36.3
		In thousands			
S/E doctorates awarded (1979-80)					
Probable Model	19.1	25.8	30.9	35.1	61.8
Static Model	21.1			22.3	46.4
Graduate S/E enrollments	240.6	341.7	469.4	42.0	95.1

Source: National Science Foundation

Chart A-1. Comparisor projectic



NOTES: S = Supply (labor force)
U = S/E utilization
* = 1969 study had one supply projection and no
SOURCE National Science Foundation

of science/engineering
-ent NSF studies,
gree

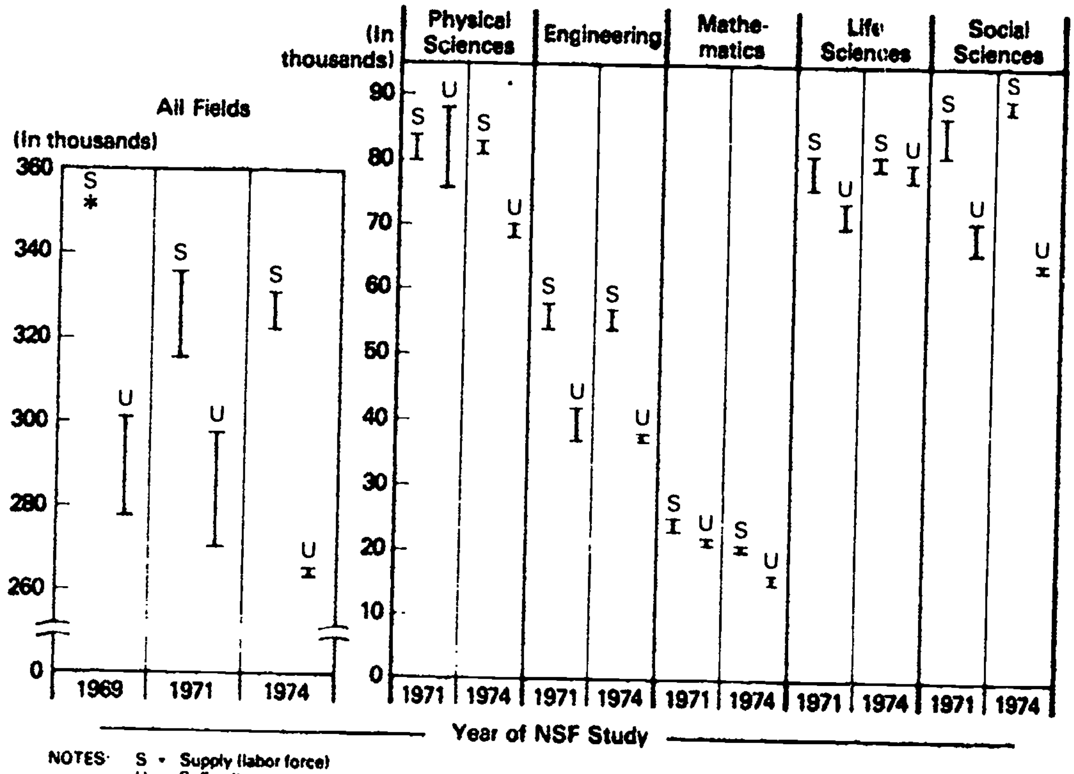
ngi-ering	Mathe-matics	Life sciences	Social sciences
rent Study			
4-37	15-16	77-80	64-65
13	12-13	55-60	49-53
-19	2	15	6
-4	1	6-5	8-6
71 Study			
-37	22-21	74-70	71-66
6	18	53-52	49-48
-13	1	14-12	9-7
-8	3-2	7-6	13-10
39 Study			
A.	N.A	N A	N A
A.	N A	N A	N A
A	N A	N A	N A
A	N A	N A	N A

ie same, one number is entered

f science/engineering
nents produced

	Percent difference between current and—	
969 report	1971 report	1969 report
:0	2.4	1 9
;2	47 3	16 4
:.4	63.7	36 3
.9	35 1	61 8
	22.3	46.4
.4	42 0	95 1

Chart A-1. Comparisons of supply and utilization projections for 1980



NOTES: S - Supply (labor force)
U - S/E utilization
* 1969 study had one supply projection and no projections for individual fields.

SOURCE National Science Foundation

2. The 1972 Base

In this study doctorate employment in a field has been essentially equated with opportunities for doctorates in the respective degree disciplines. Table 4 in chapter IV distributes each field of employment by degree and table A-4 distributes the degree holders by field of employment.

Both tables show a great deal of commonality between field of degree and occupation, on one hand, and occupation (field of employment) and field of degree on the other hand. Thus, while equating degree and future employment does not replicate the labor market precisely, it closely reflects the situation without engaging in speculation about future shifting between occupations. One source of the shifts from one field of degree to another occupation results from employer's job titling practices.

Table A-4. Science/engineering doctorates, by employment status and field of degree: 1972

Employment field status	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
	In thousands					
Total	218 7	64.3	33.7	12.7	56.1	51.9
Same field as degree	183 0	49 4	28 1	11.3	50.1	44.1
Other S E field	23 2	11 2	4 2	1.1	3.9	2.8
Non-S-E field	12 5	3.7	1 4	.3	2.1	5.0
	Percent distribution					
Total	100.0	100 0	100 0	100.0	100.0	100.0
Same field as degree	83 7	76 8	83 4	89.0	89 3	85 0
Other S/E field	10.6	17 4	12.5	8.7	7.0	5.4
Non-S/E field	5 6	5.7	4.1	2.3	3.7	9.5

Source. National Academy of Sciences *Doctoral Scientists and Engineers in the United States, 1973 Profile*. Washington, D C. 1974

3. A Market Factor Model

A recursive market model of student behavior was developed in the course of this study. This model relates the propensity of bachelor's-degree recipients to opt for graduate study to the utilization : supply ratios for doctorates, by field in each year (chart A-2). This model can be expressed mathematically as follows:

$$G^i_{Mt} = R^i_t \left(G^i_{St}\right)^n$$

$$R^i_t = \left(\frac{U^i}{L}_t\right)$$

where:

G = rate of entry to graduate school of bachelor's-degree recipients

M = market-related model

S = nonmarket-related model

R = rate of S/E utilization

U = S/E utilization

L = labor force

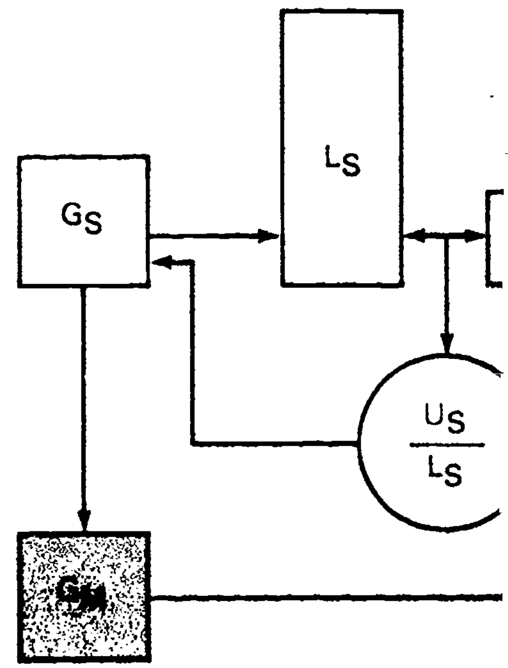
n = exponential constant

i = field of science/engineering

t = year

An attempt was made to use this model. Problems were encountered, however, in determining the value of the exponential constant. R was essentially unity during the sixties because demand for doctorates was high. In the early seventies demand softened, however, providing one data point for R which was less than unity. Obviously, these two data points (unity for the sixties and a smaller value for the early seventies) were insufficient to determine the exponent value. When further R data points with values smaller than unity become available, application of this model should be possible.

Chart A-2. Market fee



SOURCE: National Science Foundation

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bachelor's-degree recipients
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expressed mathematically as

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torates was high. In the early
e data point for R which was
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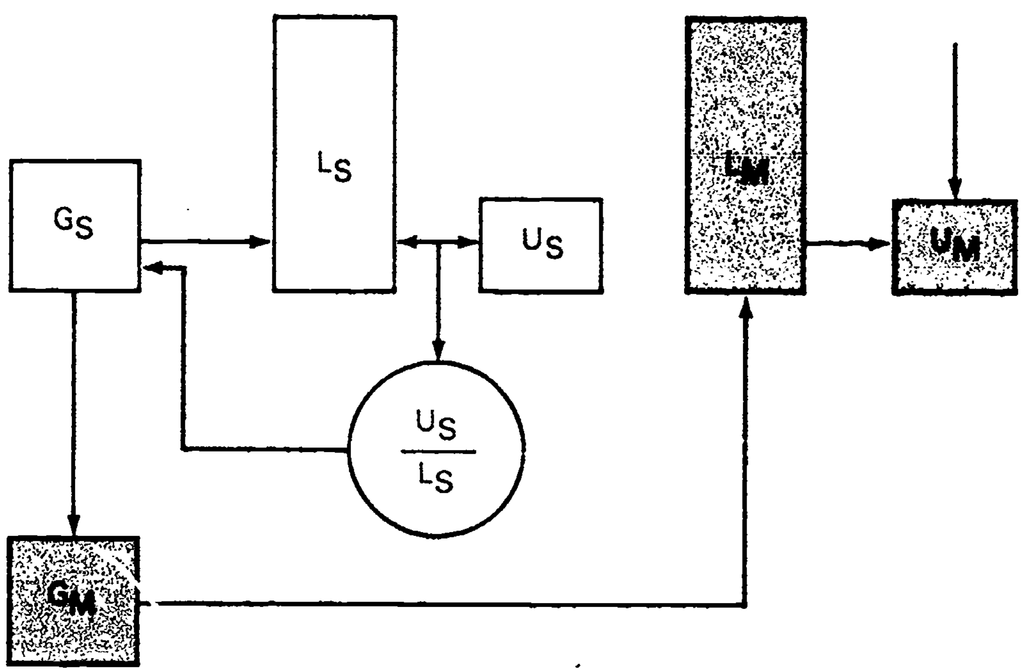
s smaller than unity become
ssible.

Chart A-2. Market feedback to supply (one stage)



L — Labor Force
U — S/E Utilization
G — $\frac{\text{Entries to Graduate School}}{\text{Baccalaureate Recipients}}$
S — Nonmarket - Related Model
M — Market Model

SOURCE: National Science Foundation

4. Supplementary Data and Methodology Descriptions for Supply and Utilization Projections

The remaining tables of this report present more detailed information on the bases of the projections (tables A-5 through A-10) and analyses of the components of the demand and utilization projections (table A-11). These tables are self-explanatory and unless otherwise noted, were developed by the National Science Foundation.

Entrance into College

Table A-5 presents projections of that part of the population which forms the predominant source of undergraduate college students, as well as the projected associated enrollments. These college enrollment projections represent all enrollments for degree credit, regardless of field of study.

As can be seen from the tabulation below, though enrollments in 2-year and 4-year institutions combined remain at about the same proportion of the 18- to 21-year-old population over the 1972 to 1985 period, enrollments will be shifting in favor of 2-year schools.

	Population 18-21 years	Percent in undergraduate schools		
		Total	4-year	2-year
1972	100.0	47.4	35 8	11.6
1974	100 0	47 0	34.9	12.1
1980	100 0	47 5	34.1	13.4
1985	100 0	47.7	33.8	13.9

Rates of entrance into college of 18-year-old population cohorts of each sex were ascertained for the period 1944-72 and then developed for the future from trend projections based on the rates of the two most recent 5-year periods by means of a straight-line least squares regression method. One projection (Probable) gives double weight to the trends of the more recent 5-year period and the other (Static, gives equal weight to the trends of both 5-year periods.

This phase of the model developed for the supply projections also indicates for each sex the time-pattern of entrance into college of those from each population cohort who ever enter. This pattern, or "spread" of entrance, has remained virtually static for each sex (except for a variation for males for a brief period in World War II and postwar years) and is held constant for the future.

The total number of entrants into cc at by summing the number of entrant cohort.[1].

[1] A distinction should be noted of the differe students. The former are persons entering college are enrolled persons who have not completed t graduate) credits without regard to the date of th

Table A-5. Projections of and enrollme

[In thou

Year	Population (by age)		
	Reaching 18 years	18 to 21 years	
1972	3,970	15.432	8
1973	4,044	15,789	8
1974	4,099	15,964	8
1975	4,194	16,318	8
1976	4 198	16,574	8,
1977	4,209	16,729	8,
1978	4,271	16,901	9
1979	4,204	16,910	9
1980	4,106	16,819	9,
1981	4,082	16,693	9
1982	4,016	16,439	8.
1983	3,843	16,078	8.
1984	3,635	15,608	8.
1985	3,498	15,025	8,

Sources: Population unpublished Bureau of th Enrollments: U.S Office of Education, *Projectior*

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re detailed information on
) and analyses of the com-
(table A-11). These tables
, were developed by the

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nent projections represent
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ugh enrollments in 2-year
he same proportion of the
eriod, enrollments will be

rgraduate schools

...year	*2-year*
35 8	11 6
34 [illegible]	12.1
34 1	13.4
33.8	13 9

opulation cohorts of each
n developed for the future
nost recent 5-year periods
method. One projection
nore recent 5-year period
ds of both 5-year periods.

pply projections also in-
nto college of those from
, or "spread" of entrance,
a variation for males for a
d is held constant for the

The total number of entrants into college for each projected year is arrived at by summing the number of entrants in that year from each relevant age-cohort.[1].

[1] A distinction should be noted of the difference between first-time entrants and first-year students The former are persons entering college (or graduate school) for the first-time. The latter are enrolled persons who have not completed the equivalent of one year's undergraduate (or graduate) credits without regard to the date of their initial entry.

Table A-5. Projections of college-age population and enrollments: 1972-85

[In thousands]

Year	Population (by age)		Degree credit college enrollments undergraduate			
	Reaching 18 years	18 to 21 years	Total	4-year	2-year	Graduate
1972	3,970	15.432	8.265	5,530	1,792	943
1973	4,044	15.789	8.370	5.549	1.858	963
1974	4.099	15.964	8.491	5.577	1,928	986
1975	4.194	16,318	8.645	5,626	2,007	1.012
1976	4.198	16.574	8.811	5.685	2.087	1.039
1977	4.209	16.729	8.965	5.745	2.154	1.066
1978	4.271	16.901	9.069	5.776	2.207	1.086
1979	4.204	16.910	9.099	5.763	2.238	1.098
1980	4.106	16.819	9.097	5.736	2.255	1.106
1981	4.082	16.693	9.051	5.682	2.261	1.108
1982	4.016	16.439	8.927	5.587	2,243	1.097
1983	3.8[illegible]3	16.078	8,746	5.450	2,203	1.093
1984	3.635	15.608	8.506	5.291	2.154	1 061
1985	3.498	15.025	8.204	5.078	2.088	1 038

Sources: Population unpublished Bureau of the Census estimates
Enrollments U S Office of Education. *Projections of Educational Statistics to 1982-83* and NSF.

Baccalaureate and First-Professional Degrees

Table A-6 presents projections of S/E bachelor's degrees. Rates of completion of undergraduate and first-professional degree education were ascertained for college entrants of each sex for the past two decades and then projected to 1985 on the basis of the male rate of the last five years, in accordance with the following rationale. At this particular stage of the higher education process, there has been no observable recent change in direction of long-term trends. The rate of attainment of baccalaureates and first-professional degrees among male college entrants has displayed only minor variations for the last 15 years and has remained completely static for the last five years at a rate slightly higher than that of the preceding five years. It was decided, therefore, to maintain the male rate constant through 1985 at the level prevailing for the last five years. Among women, the rate of attainment of baccalaureate and first-professional degrees has been rising but had not as yet reached that of males in recent years. The gap between men and women is relatively small, however, and it is assumed that the rate for women will be the same as that for men by 1985.

The time-pattern, or "spread" of completion of this stage of the higher education process is also a component of this phase of the basic model. The spread has remained constant for each sex over past years and is held at the same rates for the future.

The total number of baccalaureate and first-professional degrees for each projected year is arrived at by summing the number of such degrees earned that year by members of each relevant entrance cohort. This matrix yields Static and Probable Model projections of baccalaureate and first-professional degrees based on the input of the Static and Probable Model projections of college entrants.

Projections of bachelor's degrees by major field category are developed by disaggregating total baccalaureates for each sex on the basis of trends in the percent of baccalaureates and first-professional degrees constituted by each of the major fields in the period 1960-61 through 1970-71. The same patterns were used for both models.

Entrants Into Study for Advanced Degrees

Table A-6 also presents projections of first-time graduate students[2] and the percent of baccalaureates ever expected to enter graduate school.[3] The first-time entrants do not relate directly to undergraduate degree recipients in each year since the graduate school entrants are composed of members of a number of bachelor's-degree graduating classes. As can be seen from the indices, the propensity to enter graduate study is expected to decline.

Rates of entrance into advanced degree study were ascertained for each broad science and engineering field, for each sex, for baccalaureate cohorts of

[2] Firs' 'ime enrollees for an advanced degree.
[3] Se otnote 1, p. 31

the 20-year period ending in 1970-71. ; projections based on the rates of th straight-line, least-squares regression gives double weight to the trends of the Model projection gives equal weight periods.

For each sex-field, the percent of within specified numbers of years afte dicated. (In all sex-fields, with one exc has remained constant in the past and i number of entrants into advanced degr ming the number of entrants from eac

Table A-6. Projected science/ and first-time graduate school ent (Probabl

Academic year	Total	F
Bachelor's degree recipients		
1972-73	301.5	
1979-80	343.3	
1984-85	355.7	
First-time graduate school entrants		
1972-73	77.8	
1979-80	72.8	
1984-85	63.3	
Bachelor's degree recipients		
1979-80	113.9	
1984-85	118.0	
First-time graduate school entrants		
1979-80	93.6	
1984-85	81.4	
1972-73	26.9	
1979-80	20.4	
1984-85	16.4	

[1] Percent ever entering graduate school withou relate directly to numbers of bachelor's degree

Note: Detail may not add to totals because of

Source: National Science Foundation.

r's degrees. Rates of com-
·ree education were ascer-
two decades and then pro-
st five years, in accordance
·e of the higher education
je in direction of long-term
first-professional degrees
ior variations for the last 15
t five years at a rate slightly
ecided, therefore, to main-
l prevailing for the last five
baccalaureate and first-
et reached that of males in
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fessional degrees for each
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cohort. This matrix yields
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able Model projections of

ld category are developed
on the basis of trends in
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rough 1970-71. The same

ie graduate students[2] and
ter graduate school.[3] The
duate degree recipients in
omposed of members of a
s can be seen from the in-
pected to decline.

were ascertained for each
r baccalaureate cohorts of

the 20-year period ending in 1970-71. Future rates were developed from trend projections based on the rates of the last two five-year periods, utilizing a straight-line, least-squares regression method. The Probable Model projection gives double weight to the trends of the more recent five-year period; the Static Model projection gives equal weight to the trends of each of the five-year periods.

For each sex-field, the percent of entrants into graduate study who enter within specified numbers of years after acquisition of the baccalaureate is indicated. (In all sex-fields, with one exception, this pattern, or "spread" of entry, has remained constant in the past and is held constant for the future.) The total number of entrants into advanced degree study each year is arrived at by summing the number of entrants from each relevant baccalaureate cohort.

Table A-6. Projected science/engineering bachelor's degrees and first-time graduate school entrants, by field: 1972-73 to 1984-85 (Probable Model)

Academic year	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
	In thousands					
Bachelor s degree recipients						
1972-73	301.5	22.8	45.8	30 7	57.5	144.8
1979-80	343 3	22.3	35.5	35.7	66.4	183.3
1984-85	355 7	19.9	34.7	36.5	67.3	197.3
First-time graduate school entrants						
1972-73	77 8	11 0	16 4	9.0	15.8	25 6
1979-80	72.8	9.2	12.8	9.4	17.0	24.4
1984-85	63.3	7.5	10.5	9.2	16.5	19.7
	Indices - 1972-73 = 100 0					
Bachelor's degree recipients						
1979-80	113 9	97 8	77 5	116.3	115.5	126.6
1984-85	118.0	87.3	75.8	118.9	117.0	136.3
First-time graduate school entrants						
1979-80	93 6	83 6	78 1	104.4	107 6	95.3
1984-85	81 4	68 2	64 0	102.2	104.4	77 0
	Percent of graduates ever entering graduate school[1]					
1972-73	26 9	47 7	36 5	30 3	30 0	18.7
1979-80	20 4	39 4	31.9	27 1	25.8	12.6
1984-85	16 4	32.7	28.0	24.0	23.3	8.9

[1] Percent ever entering graduate school without respect to year of entry These percents do not relate directly to numbers of bachelor's degrees and graduate school entrants shown above.

Note Detail may not add to totals because of rounding

Source National Science Foundation

Doctorate Degrees

Table A-7 continues to follow students through the educational process, showing the proportions of graduate entrants projected to receive doctorates. In the Probable supply projection the success quotients are projected to decline. In the Static Model, however, the decline is slight, with engineering, and life and social sciences projected to exhibit growing success ratios.

The rate of attainment of the Ph.D. among entrants into advanced degree study was determined for each broad science field, by sex, for graduate-study entrants of the period of the midfifties to the midsixties. (The period varied slightly by sex-field.) Rates of acquisition of the degree were developed in relation to number of Ph.D.'s earned, as reported by the U.S. Office of Education, through academic year 1970-71,[4] the latest year for which Office of Education data are available. Two more years of data on rate of attainment of the degree were developed by utilizing earned Ph.D. data for academic years 1971-72 and 1972-73 reported by the National Research Council (NRC),[5] via a method of relating past rates based on NRC data to rates for the same years based on U.S. Office of Education data.

Future rates were developed from trend projections of past rates utilizing a straight-line, least-squares regression technique. Trends of more recent years of the period for which data are available were given double weight in combination with trends of earlier years in the Probable Model and equal weight in the Static Model.

Analyses were carried out to determine, by sex and field, the percentages of entrants acquiring a Ph.D. degree within certain numbers of years after graduate school entry. This pattern, or "spread" of acquisition of the degree, has remained almost constant in the past and is held constant for the future. In each sex-field, the total number of Ph.D.'s earned each year is arrived at by summing the number of Ph.D.'s earned that year by members of each relevant entry cohort.

[4] U S Office of Education *Earned Degrees Conferred* annual series. (Washington, D.C. 20402: Supt of Documents. U S Government Printing Office)

[5] National Academy of Sciences. National Research Council. *Doctorate Recipients from United States Universities*. annual series (Washington. D.C.. 20418.)

Table A-7. Projections of the pr graduate school who will ever ear 1972-73 t

Academic year of graduate school entry	Total	P sc
1972-73	25.6	
1979-80	22.7	
1984-85	20.7	
1972-73	28.1	
1979-80	27.9	
1984-85	27.6	

Source National Science Foundation.

ı the educational process, ;ted to receive doctorates. uotients are projected to s slight, with engineering, owing success ratios.

;nts into advanced degree ›y sex, for graduate-study ixties. (The period varied ee were developed in rela- ‡U.S. Office of Education. which Office of Education ·f attainment of the degree ademic years 1971-72 and :l (NRC),[5] via a method of : same years based on U.S.

ɔns of past rates utilizing a ends of more recent years double weight in combina- ;el and equal weight in the

and field, the percentages :n numbers of years after acquisition of the degree. : constant for the future. In each year is arrived at by members of each relevant

series. (Washington. D C 20402·

Doctorate Recipients from United

Table A-7. Projections of the proportions of students entering graduate school who will ever earn doctorates, by field and model: 1972-73 to 1984-85

Academic year of graduate school entry	Total	Physical sciences	Engineering	Mathematics	Life sciences	Social sciences
	Probable Supply Projection					
1972-73	25 6	28 4	19.4	12 1	31.1	29 6
1979-80	22.7	20.1	18.2	6.2	28.5	28.3
1984-85	20.7	14.6	18.0	2.7	26.7	28.0
	Static Supply Projection					
1972-73	28.1	30.4	21.2	12.1	35.4	32.7
1979-80	27 9	25.1	23.5	6.9	35.2	34.6
1984-85	27 6	21 7	24.6	3 4	36.0	36.0

Source. National Science Foundation.

Projections of Overall S/E Employment

Table A-8 presents the overall projections of S/E employment to 1985, regardless of degree level. The total S/E employment projections represent the sum of projections made for each activity component. Projections for academic. nonacademic R&D. and other S/E employment were developed with the methodologies described in chapter VI.

Table A-8. Projected total scientist/engineer employment, by activity: 1972-85

Year	Total	Academic[1]			Nonacademic	
		Total	4-year	2-year	R&D	Other
	In thousands					
1972	1.700	281	247	34	447	972
1980	1.942	298	253	45	459	1,185
1985	2.103	270	228	42	493	1,340
	Percent distribution					
1972	100 0	16 5	14.5	2.0	26.3	57.2
1980	100 0	15 4	13 0	2.4	23 6	61.0
1985	100 0	12.9	10.9	2.0	23.4	63.7
	Average annual percent change					
1972-80	1 7	0 7	0.3	3.6	0.3	2.5
1980-85	1 0	−2.0	−2.1	−1.4	1.4	2.5
1972-85	1 6	−.3	−.6	1 6	.8	2.5

[1] Excludes employed graduate students

Note Detail may not add to totals because of rounding

Sources National Science Founndation and Bureau of Labor Statistics.

Table A-9. Projections of R&D scientist/engineer employ

Sector of R&D performance	1972
Expenditures	Billions of
Total	$29.1
Industry	19.5
Federal Government	4.5
Universities[1]	4.0
Nonprofit organizations	1.1
Employment (full-time equivalent)	In the
Total	508
Industry	357
Federal Government	68
Universities[1]	61
Nonprofit organizations	22

[1] Includes Federally Funded Research and De

Source: National Science Foundation.

ı/E employment to 1985, projections represent the ponent. Projections for nent were developed with

engineer
-85

	2-year	Nonacademic R&D	Other
usands			
	34	447	972
	45	459	1,185
	42	493	1,340
istribution			
	2 0	26 3	57 2
	2.4	23 6	61 0
	2.0	23 4	63.'
percent change			
	3.6	0.3	2 5
	−1.4	1.4	2.5
	1 6	.8	2 5

ıtatistics

Table A-9. Projections of R&D expenditures and total R&D scientist/engineer employment, by sector: 1972-85

Sector of R&D performance	1972	1980	1985	1972	1985	Average annual percent change 1972-85
Expenditures	Billions of 1972 dollars			Percent distribution		
Total	$29.1	$31.1	$34.7	100.0	100.0	1.4
Industry	19.5	20 8	23.1	67.0	66.6	1.3
Federal Government	4 5	4 9	5.4	15.5	15.6	1 4
Universities'	4.0	4 3	4.9	13.7	14.1	1.5
Nonprofit organizations	1.1	1 1	1.1	3.8	3.7	1.3
Employment (full-time equivalent)	In thousands					
Total	508	521	560	100.0	100.0	0.8
Industry	357	368	396	70.3	70.7	.8
Federal Government	68	68	73	13.4	13.0	.6
Universities'	61	62	67	12.0	12.0	.7
Nonprofit organizations	22	22	24	4.3	4.3	.7

' Includes Federally Funded Research and Development Centers administered by universities.

Source: National Science Foundation

Table A-10. Projected science/engineering enrollments and total faculty, by level and field:[1] 1973-85

[In thousands]

Academic Year	Total: Total	Total: Under-graduate	Total: Graduate	Physical sciences: Total	Physical sciences: Under-graduate	Physical sciences: Graduate	Engineering: Total	Engineering: Under-graduate	Engineering: Graduate	Mathematics: Total	Mathematics: Under-graduate	Mathematics: Graduate	Life: Total	Life: U gr
								Enrollments						
Probable Model														
1972-73	1.943 3	1.693 9	249.4	168.8	130.4	38.4	325.8	271.0	54.8	199.2	169.4	29.8	371.2	3
1979-80	2.00? 4	1.761 8	240 6	147.9	114.4	33.5	285.4	242.9	42.5	201.0	169.0	32.0	384.0	3
1984-85	1,807.4	1,590.3	217.1	116.4	89.2	27.2	230.3	192.6	37.7	181.8	149.6	32.2	345.0	2
								Faculty[2]						
1972-73	246.6	174 7	71 9	32 3	17.7	14.6	23.1	17.4	5.7	19 0	13 8	5.2	105.5	[illegible]
1979-80	253 0	179 6	73 4	28.4	15.5	12.9	20.0	15.6	4.4	19.3	13.7	5.6	111.4	7
1984-85	227.9	160.3	67.6	22.6	12.1	10.5	16.2	12.3	3.9	17.8	12.2	5.6	102.0	6
								Enrollments						
Static Model														
1979-80	2,090 6	1,815.0	275.6	157 2	118 2	39.0	300.8	251.1	49.7	210.7	174.0	36.7	399.2	33
1980-85	2,014.1	1,722.8	291.3	134 7	96.8	37.9	262.6	209.5	53.1	204.8	161.9	42.9	380.3	3
								Faculty[2]						
1979-80	267 7	185.0	82.7	31.0	16.0	15.0	21.3	16.1	5.2	20.5	14.1	6.4	117.1	7
1980-85	260 9	173.7	87 2	27.7	13.1	14.6	18.9	13.4	5.5	20.7	13.2	7.5	114.8	7

[1] In 4-year colleges and universities

[2] Full-time- equivalent faculty

Source National Science Foundation

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Table A-10. Projected science/engineering enrollments and total faculty, by level and field:[1] 1973-85

[In thousands]

ʼhysical sciences			Engineering			Mathematics			Life sciences			Social sciences		
l	Under-graduate	Graduate	Total	Under-graduate	Graduate	Total	Under-graduate	Graduate	Total	Under-graduate	Graduate	Total	Under-graduate	Graduate
Enrollments														
8	130 4	38 4	325.8	271.0	54.8	199.2	169.4	29.8	371 2	320.1	51.1	878.3	803.0	75.3
9	114 4	33.5	285.4	242.9	42.5	201 0	169 0	32 0	384.0	329.1	54.9	984.1	906.4	77.7
4	89.2	27.2	230.3	192.6	37.7	181.8	149.6	32.2	345.0	291.3	53.7	933.9	867.6	66.3
Faculty[2]														
3	17 7	14.6	23.1	17.4	5.7	19 0	13.8	5.2	105.5	72.5	33.0	66.7	53.3	13.4
4	15 5	12 9	20.0	15.6	4.4	19.3	13.7	5.6	111.4	74.8	36.6	73.9	60.0	13.9
6	12.1	10.5	16.2	12.3	3.9	17.8	12.2	5 6	102.0	66.2	35.8	69 3	57.5	11.8
Enrollments														
2	118 2	39.0	300.8	251.1	49 7	210.7	174.0	36.7	399.2	339.3	59.9	1,022.7	932.4	90.3
7	96 8	37.9	262.6	209.5	53.1	204 8	161.9	42 9	380.3	315.8	64.5	1,031.7	938.8	92.9
Faculty[2]														
0	16.0	15.0	21.3	16.1	5.2	20 5	14 1	6.4	117.1	77.1	40.0	77.8	61.7	16.1
7	13 1	14 6	18.9	13.4	5.5	20 7	13 2	7 5	114.8	71.8	43.0	78.8	62.2	16.6

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Table A-11. Components of incremental utilization of science/engineering doctorates, by field of degree and activity, 1972-85 (Probable Model)

Field/component	In thousands: Total	In thousands: Academic	In thousands: Non-academic R&D	In thousands: Other science/engineering	In thousands: Non-science/engineering	Percent distribution: Total	Percent distribution: Academic	Percent distribution: Non-academic R&D	Percent distribution: Other science/engineering	Percent distribution: Non-science/engineering	Total
Total, all fields	218.5	61.0	49.1	30.3	78.0	100.0	27.9	22.5	13.9	35.7	100.0
Growth	153.5	31.6	31.7	23.0	67.1	100.0	20.6	20.7	15.0	43.7	70.3
Replacement[2]	65.0	29.4	17.4	7.3	10.9	100.0	45.2	26.8	11.2	16.8	29.7
Physical sciences	38.2	2.0	22.3	7.8	6.1	100.0	5.2	58.4	20.4	16.0	100.0
Growth[1]	19.9	—4.3	13.9	5.8	4.5	100.0	—21.6	69.8	29.1	22.6	52.1
Replacement[2]	18.3	6.3	8.4	2.0	1.6	100.0	34.4	45.9	10.9	8.7	47.9
Engineering	38.0	2.6	11.6	5.5	18.3	100.0	6.8	30.5	14.5	48.2	100.0
Growth[1]	29.3	.1	8.1	4.4	16.7	100.0	.3	27.6	15.0	57.0	77.1
Replacement[2]	8.7	2.5	3.5	1.1	1.6	100.0	28.7	40.2	12.6	18.4	22.9
Mathematics	11.9	4.5	1.2	0.6	5.6	100.0	37.8	10.1	5.0	47.1	100.0
Growth[1]	8.7	2.1	0.8	0.5	5.3	100.0	24.1	9.2	5.7	60.9	73.1
Replacement[2]	3.2	2.4	0.4	0.1	0.3	100.0	75.0	12.5	3.1	9.4	26.9
Life sciences	53.3	28.7	10.1	7.2	7.3	100.0	53.8	18.9	13.5	13.7	100.0
Growth[1]	35.4	19.5	6.3	5.3	[illegible]	100.0	55.1	17.8	15.0	12.1	66.4
Replacement[2]	17.9	9.2	3.8	1.9	[illegible].0	100.0	51.4	21.2	10.6	16.8	33.6
Social sciences	77.1	23.2	3.9	9.3	40.7	100.0	30.1	5.1	12.1	52.8	100.0
Growth[1]	60.2	14.2	2.6	7.1	36.3	100.0	23.6	4.3	11.8	60.3	78.1
Replacement[2]	16.9	9.0	1.3	2.2	4.4	100.0	53.3	7.7	13.0	26.0	21.9

[1] Includes enrichment

[2] Replacement of doctorates only

Source: National Science Foundation

-11. Components of incremental utilization of science/engineering -rates, by field of degree and activity, 1972-85 (Probable Model)

ɔusands			Percent distribution					Percent distribution				
·· ͫnic)	Other science/ engineering	Non-science/ engineering	Total	Academic	Non-academic R&D	Other science/ engineering	Non-science/ engineering	Total	Academic	Non-academic R&D	Other science/ engineering	Non-science/ engineering
	30.3	78.0	100.0	27.9	22.5	13.9	35.7	100.0	100.0	100.0	100.0	100.0
	23.0	67.1	100.0	20.6	20.7	15.0	43.7	70.3	51.8	64.6	75.9	86.0
	7.3	10.9	100.0	45.2	26.8	11.2	16.8	29.7	48.2	35.4	24.1	14.0
	7.8	6.1	100.0	5.2	58.4	20.4	16.0	100.0	100.0	100.0	100.0	100.0
	5.8	4.5	100.0	−21.6	69.8	29.1	22.6	52.1	−215.0	62.3	74.4	73.8
	2.0	1.6	100.0	34.4	45.9	10.9	8.7	47.9	315.0	37.7	25.6	26.2
	5.5	18.3	100.0	6.8	30.5	14.5	48.2	100.0	100.0	100.0	100.0	100.0
	4.4	16.7	100.0	3	27.6	15.0	57.0	77.1	3.8	69.8	80.0	91.3
	1.1	1.6	100.0	28.7	40.2	12.6	18.4	22.9	96.2	30.2	20.0	8.7
	0.6	5.6	100.0	37.8	10.1	5.0	47.1	100.0	100.0	100.0	100.0	100.0
	0.5	5.3	100.0	24.1	9.2	5.7	60.9	73.1	46.7	66.7	83.3	94.6
	0.1	0.3	100.0	75.0	12.5	3.1	9.4	26.9	53.3	33.3	16.7	5.4
	7.2	7.3	100.0	53.8	18.9	13.5	13.7	100.0	100.0	100.0	100.0	100.0
	5.3	4.3	100.0	55.1	17.8	15.0	12.1	66.4	67.9	62.4	73.6	58.9
	1.9	3.0	100.0	51.4	21.2	10.6	16.8	33.6	32.1	37.6	26.4	41.1
	9.3	40.7	100.0	30.1	5.1	12.1	52.8	100.0	100.0	100.0	100.0	100.0
	7.1	36.3	100.0	23.6	4.3	11.8	60.3	78.1	61.2	66.7	76.3	89.2
	2.2	4.4	100.0	53.3	7.7	13.0	26.0	21.9	38.8	33.3	23.7	10.8

APPENDIX B
Selected Related Publications

Bailey D. and C. Schotta,"Private and S
Academicians,)) *The American Ecc*
to this article by L. Figa-Talaman
Economic Review (March 1974)

Becker, Gary S., *Human Capital: A Th*
Special Reference to Education. Ne
Research, 1964.

Berg, Ivar, *Education and Jobs: The*
Praeger Publishers, 1970.

Blank, David M. and George J. Stigler,
Personnel. New York: National Bur

Breneman, David W., *An Economic The*
Berkeley. Berkeley, Calif: Ford Fou
iversity Administration, 1970.

______________, *The Ph.D. Productic*
Berkeley, Calif: Ford Foundation Pr
ministration, 1970.

Brode, Wallace, "Manpower in Science
tion Model," *Science* 173 (July 16,

Brooks, Harvey, "What's Happening to t
Business Review (May-June 1972).

The Carnegie Commission on Higher Ec
Adjusting to a New Labor Market Si

______________, *The More Effective L*
Higher Education. New York: McG

Cartter, Allan M., "Scientific Manpower
1971).

______________, "The Supply of and De
of Human Resources 1 (1966).

______________, "Future Faculty Needs a
proving College Teaching. Wash
Education, 1966.

Cheit, Earl, *New Depression in Higher*
1971.

Colorado Commission on Higher E
Workbook. Denver, Colo.: Colorad
1973.

Bailey D. and C. Schotta, "Private and Social Rates of Return to Education of Academicians,)) *The American Economic Review* (March 1972) and Notes to this article by L. Figa-Talamanca and J.S. Tomaske, *The American Economic Review* (March 1974)

Becker, Gary S., *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*. New York: National Bureau of Economic Research, 1964.

Berg, Ivar, *Education and Jobs: The Great Training Robbery*. New York: Praeger Publishers, 1970.

Blank, David M. and George J. Stigler, *The Demand and Supply of Scientific Personnel*. New York: National Bureau of Economic Research, 1957.

Breneman, David W., *An Economic Theory of Ph.D. Production: The Case at Berkeley*. Berkeley, Calif: Ford Foundation Program for Research in University Administration, 1970.

———, *The Ph.D. Production Function: The Case at Berkeley*. Berkeley, Calif: Ford Foundation Program for Research in University Administration, 1970.

Brode, Wallace, "Manpower in Science and Engineering, Based on a Saturation Model," *Science* 173 (July 16, 1971).

Brooks, Harvey, "What's Happening to the U.S. Lead in Technology?" *Harvard Business Review* (May-June 1972).

The Carnegie Commission on Higher Education, *College Graduate and Jobs, Adjusting to a New Labor Market Situation*. New York: McGraw-Hill, 1973.

———, *The More Effective Use of Resources, An Imperative for Higher Education*. New York: McGraw-Hill, 1972.

Cartter, Allan M., "Scientific Manpower for 1970-1985," *Science* 172 (9 April 1971).

———, "The Supply of and Demand for College Teachers," *Journal of Human Resources* 1 (1966).

———, "Future Faculty Needs and Resources" in Calvin Lee (ed.) *Improving College Teaching*. Washington, D.C.: American Council on Education, 1966.

Cheit, Earl, *New Depression in Higher Education*. New York: McGraw-Hill, 1971.

Colorado Commission on Higher Education, *1973 Faculty Workload Workbook*. Denver, Colo.: Colorado Commission on Higher Education, 1973.

APPENDIX B

d Publications

Committee for Economic Development, *Sources of Economic Growth and the Alternatives Before Us*. New York: Committee for Economic Development, 1962.

Council of Economic Advisors, *Economic Report of the President*. Washington, D.C. 20402: Supt. of Document, U.S. Government Printing Office, Feb. 1974.

Denison, Edward F., *Sources of Economic Growth in the United States and Alternatives Before Us*. New York: Committee for Economic Development, 1962.

DeWitt, Laurence B. and A. Dale Tussing, *The Supply and Demand for Graduates of Higher Education: 1970 to 1980*. Syracuse, N.Y.: Syracuse University Research Corporation, 1971.

Falk, Charles E., "Dynamics and Forecasts of R&D Funding," *Technological Forecasting and Social Change 6*. New York: American Elsevier Publishing Company, 1974.

Freeman, Richard B., *Engineers and Scientists in the Industrial Economy* (unpublished).

____________. *The Market for College-Trained Manpower, A Study in the Economics of Career Choice*. Cambridge, Mass.: Harvard University Press, 1971.

Freeman, Richard B. and David W. Breneman, *Forecasting the Ph.D. Labor Market. Pitfalls for Policy*. Washington, D.C.: National Board on Graduate Education, 1974.

Fullerton, Howard N., Jr., "A New Type of Working Life Table for Men," *Monthly Labor Review* (July 1972).

Ginsberg, Eli, "The Outlook for Educated Manpower," *Public Interest* 26 (Winter 1972).

Hansen, W. Lee (ed.), *Education, Income and Human Capital*. New York: Columbia University Press, 1970.

Industrial Research Institute, *Utilization of and Demand for Engineers and Scientists in Industrial Research*. New York: Industrial Research Institute, 1973.

Department of Health, Education, and Welfare, Office of Education, *Earned Degrees Conferred*, annual. Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office.

____________, *The Education Professions - 1971-72, Part I - The Need for Teachers in Our Schools and Colleges*. Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1972.

____________, *Enrollment for Advan*
20402: Supt. of Documents, U.S. (

____________, *Opening Fall Enrolln*
Supt. of Documents, U.S. Govern

____________, *Projections of Educati*
D.C. 20402: Supt. of Documents,

Johnston, Denis F., "The Future of Wo
ly Labor Review (May 1972).

____________, "The U.S. Economy in
jections," *Monthly Labor Review*

Kutscher, Ronald E., "The U.S. Econor
Output, and Employment," *Month*

Department of Labor, Bureau of Labo,
Washington, D.C. 20402: Supt. of
Office, Nov. 1973.

____________, *The U.S. Economy in*
20402: Supt. of Documents, U.S. (

National Academy of Sciences, Na
Recipients From United States U
Washington, D.C., 1967.

____________, *Doctoral Scientists and*
Profile. Washington, D.C., March

____________, *The Invisible Universit*
States. Washington, D.C., 1969.

____________, *Summary Report*
Washington, D.C.

National Board on Graduate Educa
Problems, and Potential. Washing

National Science Board, *Seminar on S*
jections (in press). Washington,
Government Printing Office, 1975

____________, *Science Indicators, 19*
Supt. of Documents, U.S. Govern

National Science Foundation, *Gradua*
and Postdoctorals, Fall 1972 (NSF
of Documents, U.S. Government

____________, Detailed Statistic
Student Support and Postdoctora
volume). Washington, D.C. 2055(

)f Economic Growth and the
for Economic Development,

Report of the President.
t, U.S. Government Printing

·th in the United States and
for Economic Development,

: Supply and Demand for
). Syracuse, N.Y.: Syracuse

D Funding," *Technological*
York: American Elsevier

the Industrial Economy (un-

: *Manpower, A Study in the*
Mass.: Harvard University

'orecasting the Ph.D. Labor
National Board on Graduate

LifeTable for Men," *Month-*

ipower," *Public Interest* 26

Human Capital. New York:

Demand for Engineers and
ndustrial Research Institute,

Office of Education, *Earned*
. 20402: Supt. of Documents,

71-72, Part I - The Need for
ington, D.C. 20402: Supt. of
e, 1972.

__________, *Enrollment for Advanced Degrees*, annual. Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office.

__________, *Opening Fall Enrollment*, annual. Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office.

__________, *Projections of Educational Statistics to 1982-83*. Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1974.

Johnston, Denis F., "The Future of Work: Three Possible Alternatives," *Monthly Labor Review* (May 1972).

__________, "The U.S. Economy in 1985, Population and Labor Force Projections," *Monthly Labor Review* (December 1973).

Kutscher, Ronald E., "The U.S. Economy in 1985, Projections of GNP, Income, Output, and Employment," *Monthly Labor Review* (December 1973).

Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*. Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, Nov. 1973.

__________, *The U.S. Economy in 1985*, Bulletin 1809. Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1974.

National Academy of Sciences, National Research Council, *Doctorate Recipients From United States Universities, 1958-1966*, Publ. No. 1489. Washington, D.C., 1967.

__________, *Doctoral Scientists and Engineers in the United States: A 1973 Profile*. Washington, D.C., March 1974.

__________, *The Invisible University, Postdoctoral Education in the United States*. Washington, D.C., 1969.

__________, *Summary Report of Doctorate Recipients*, annual. Washington, D.C.

National Board on Graduate Education, *Graduate Education: Purposes, Problems, and Potential*. Washington, D.C. 1972.

National Science Board, *Seminar on Scientific and Technical Manpower Projections* (in press). Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1975.

__________, *Science Indicators, 1972* (NSF 73-1). Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1973.

National Science Foundation, *Graduate Science Education: Student Support and Postdoctorals, Fall 1972* (NSF 73-315). Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office. 1974.

__________, Detailed Statistical Tables, *Graduate Science Education: Student Support and Postdoctorals, Fall 1973 (NSF 74-318 A)* (separate volume). Washington, D.C. 20550, 1974.

———. *Science Resources Studies Highlights*, "1973 Graduate Science Enrollment Down Another 2 Percent" (NSF 74-308). Washington, D.C. 20550, July 30, 1974.

———. *Science Resources Studies Highlights*, "Graduate Enrollment Up in Biological Sciences, Fall 1974" (NSF 74-321). Washington, D.C. 20550, December 31, 1974.

———. *National Patterns of R&D Resources, 1953-1974. Funds & Manpower in the United States* (NSF 74-304). Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1974.

———. *Research and Development in Industry, 1972. Funds, 1972; Scientists & Engineers, Jan. 1973* (NSF 73-312). Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1974.

———. *Resources for Scientific Activities at Universities and Colleges, 1969* (NSF 70-16). Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1969.

———. *R&D Projections—1980 and 1985* (in preparation).

———. *Science Resources Studies Highlights*, "20-Percent Increase in Energy Activity Paces Industrial R&D Spending in 1973" (NSF 74-319). Washington, D C. 20550, December 4, 1974.

———. *Resources for Scientific Activities at Universities and Colleges, 1971* (NSF 72-315). Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1973.

———. *Science Resources Studies Highlights*, "Academic R&D Expenditures Reached $3.3 Billion in 1972" (NSF 73-308). Washington, D.C. 20550, August 13, 1973.

———. *Science Resources Studies Highlights*, "Academic R&D Expenditures Up 9 Percent in 1973" (NSF 74-306). Washington, D.C. 20550, May 8, 1974.

———. *Science Resources Studies Highlights*, "Employment of Life Scientists Up in 1974—Accounts for Nearly All Growth of Scientists and Engineers in Doctorate-Granting Institutions" (NSF 74-315). Washington, D.C. 20550, October 1, 1974.

———. Detailed Statistical Tables. *Manpower Resources for Scientific Activities at Universities and Colleges. January 1974* (NSF 75-300-A). Washington, D.C. 20550, 1974.

——— *Science & Engineering Doctorate Supply & Utilization, 1968-80* (NSF 69-37). Washington, D.C. 20402: Supt of Documents, U.S. Government Printing Office, 1969.

———, *1969 & 1980 Science* *Utilization* (NSF 71-20). Washingtc U.S. Government Printing Office, 1

———, *A Price Index for Defla* (NSF 72-310). Washington, D.C. 204 ment Printing Office, 1972.

———, *Scientific Human Resc* 304). Washington, D.C. 20402: Su Printing Office, 1972.

O'Connell, John F., "The Labor Ma Methodology," *The Journal of Hum*

Powel, John H. Jr., and Robert D. Lan *Literature Relating to the Costs a* Washington, D.C.: The Council of G

———, *Elements Related t* *Benefits of Graduate Education.* Graduate Schools, 1972.

Rosenthal, Neal H., "The U.S. Econom cupations," *Monthly Labor Review*

Solomon, Lewis C. and Paul J. Taubm *Evidence on the Impacts of Higher E* 1973.

"Special Issue: Psychology's Manpower: chologists," *American Psychologis* relating to subjects such as "The Ac Projections," by Kenneth B. Little, Ri and others.)

Special Task Force to the Secretary of He *America*. Cambridge, Mass.: The M

Weathersby, George B., *Structural Issues* *tific Manpower: Implications for N* Calif.: Ford Foundation Program fo tion, May 1972.

Wilson, Logan (ed.), *Universal Higher E* Washington, D.C.: American Counc

Withey, Stephen B., *A Degree and What E* *a College Education*. New York: Mc

Wolfe, Dael and Charles V. Kidd, "The Fu (August 27, 1971).

Highlights, "1973 Graduate
" (NSF 74-308). Washington,

lights, "Graduate Enrollment
· 74-321). Washington, D.C.

ources, 1953-1974. Funds &
4). Wasnington, D.C. 20402:
ing Office. 1974.

Industry, 1972. Funds, 1972;
i2). Washington, D.C. 20402:
ing Office, 1974.

ivities at Universities and
. 20402: Supt. of Documents,

5 (in preparation).

lights, "20-Percent Increase
ıding in 1973" (NSF 74-319).

ivities at Universities and
›n, D.C. 20402: Supt. of
ə, 1973.

ılights, "Academic R&D Ex-
₋ 73-308). Washington, D.C.

ılights, "Academic R&D Ex-
3). Washington, D.C. 20550,

lights, "Employment of Life
ıll Growth ot Scientists and
(NSF 74-315). Washington,

ower Resources for Scien-
ıuary 1974 (NSF 75-300-A).

Supply & Utilization, 1968-
Supt. of Documents, U.S.

———, *1969 & 1980 Science & Engineering Doctorate Supply & Utilization* (NSF 71-20). Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1971.

———. *A Price Index for Deflation of Academic R&D Expenditures* (NSF 72-310). Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1972.

———, *Scientific Human Resources: Profiles and Issues* (NSF 72-304). Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1972.

O'Connell, John F., "The Labor Market for Engineers: An Alternative Methodology," *The Journal of Human Resources* VIII (Winter 1972).

Powel, John H. Jr., and Robert D. Lamson, *An Annotated Bibliography of Literature Relating to the Costs and Benefits of Graduate Education*. Washington, D.C.: The Council of Graduate Schools, 1972.

———, *Elements Related to the Determination of Costs and Benefits of Graduate Education*. Washington, D.C.: The Council of Graduate Schools, 1972.

Rosenthal, Neal H., "The U.S. Economy in 1985, Projected Changes in Occupations," *Monthly Labor Review* (December 1973).

Solomon, Lewis C. and Paul J. Taubman (ed.), *Does College Matter, Some Evidence on the Impacts of Higher Education*. New York: Academic Press, 1973.

"Special Issue: Psychology's Manpower: The Education and Utilization of Psychologists," *American Psychologist 27* (May 1972). (Various articles relating to subjects such as "The Academic Marketplace," "Salaries, and Projections," by Kenneth B. Little, Richard B. Freeman, Alexander W. Astin and others.)

Special Task Force to the Secretary of Health, Education, and Welfare, *Work in America*. Cambridge, Mass.: The MIT Press, 1973.

Weathersby, George B., *Structural Issues in the Supply and Demand for Scientific Manpower: Implications for National Manpower Policy*. Berkeley, Calif.: Ford Foundation Program for Research in University Administration, May 1972.

Wilson, Logan (ed.), *Universal Higher Education: Costs, Benefits, Options*. Washington, D.C.: American Council on Education, 1972.

Withey, Stephen B., *A Degree and What Else? Correlates and Consequences of a College Education*. New York: McGraw-Hill, 1971.

Wolfe, Dael and Charles V. Kidd, "The Future Market for Ph.D.'s," *Science* 173 (August 27, 1971).